PUBLIC LIBRARY

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

AUGUST 1957

ICBM: Giant Step into Space..... *Simon Ramo*

Propellants for Tomorrow's Rockets..... *Fritz Zwicky*

Special 14-page IGY Report

rocket power
from reasoning power

A *reasoning* mind—man has always found this his most useful weapon when venturing into unknown fields. Today's frontier—one of the greatest unknowns ever faced by man—lies in outer space.

RMI, America's *first* rocket family, is uniquely qualified to help our country conquer the new frontier. For this project will require more powerful and more efficient rocket propulsion systems than any yet designed. And RMI's experience in the rocket power field extends back over 15 years . . . years in which RMI scientists and engineers pooled their reasoning power and knowledge to develop entirely new methods of propulsion and to produce rocket powerplants for dozens of military vehicles.

With this backlog of experience—and with an increasing staff of imaginative, reasoning engineers—RMI continues to blaze trails in many fields of rocket power: supersonic manned aircraft . . . versatile helicopters . . . catapults and test sleds . . . and missiles for defense and space exploration.

Engineers, Scientists—Perhaps you, too, can work with America's *first* rocket family. You'll find the problems challenging, the rewards great.

Power for Progress

®RMI

REACTION MOTORS, INC.

A MEMBER OF THE OMAR TEAM

DENVILLE, NEW JERSEY

4874

B-13

engineers agree

Not on tobacco blends—
nor sources of energy—
but every day,
throughout the industry
Engineers agree
on Wiggins Connectors.

Wiggins

The authority on connectors
Engineered for Reliability.

E. B. Wiggins Oil Tool Company, Inc.
3424 East Olympic Blvd., Los Angeles 23, Calif.

THIS JOB CAN'T WAIT!

The computer system for the Intermediate Range and Intercontinental Ballistic Missiles being built by Remington Rand Univac is vital to national defense.

The United States must be ready to deliver a swift and crushing counterpunch in case of enemy attack. The Univac® system would guide such missiles as the Air Force's TITAN and THOR on their missions of retribution.

There is immediate need for qualified men in Univac's highly essential ICBM program. Here is your opportunity to take part in a fascinating, crucially important project . . . your opportunity to find a permanent position and limitless future with Univac — world leader in the field of electronic computers.

Immediate Openings for:

ELECTRONIC ENGINEERS for component engineering, transistor circuit applications, circuit analysis and design, reliability, engineering test, component evaluation, quality control and specifications.

MATHEMATICIANS, BS, MS, and PhD levels for programming, math research, statistical analysis, data conversion. One to seven years' experience.

PHYSICISTS, BS, MS, PhD levels for research and development of systems and circuitry of digital computers, for evaluation of component reliability, and for physical research including evaporative thin film research and other solid state phenomena.

Also, other non-military career openings at our laboratories in Philadelphia, Pa., Norwalk, Conn., and St. Paul, Minn.

Send complete resumé to:

Remington Rand Univac

DIVISION OF SPERRY RAND CORPORATION

MR. H. A. POENACK
Dept. S8-40
Univac Park • St. Paul 16, Minn.

Registered U. S. Patent Office

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC.

August 1957 *volume 2 number 1*

Editor
IRWIN HERSEY

Managing Editor
MICHAEL L. YAFFEE

Technical Editor
MARTIN SUMMERFIELD

Associate Editor
ROBERT C. TOTH

Research Editor
GEORGE F. McLAUGHLIN

Assistant Editor
LARKIN JOYNER

Art Director
JOHN CULIN

Contributors
John Gustavson, Andrew G. Haley, Robert H. Kenmore, K. R. Stehling

Correspondents
Rodney D. Stewart, Alabama; Donald L. Dynes, Antelope Valley; William C. Ruckert, Central Colorado; T. E. Farmer, Central Texas; Harold W. Schmidt, Cleveland-Akron; James L. Harp, Columbus; Charles Gibson, Detroit; Sidney F. Spear, Florida; James S. Hanrahan, Holloman AFB; Milton Rogers, Maryland; G. Harry Stine, New Mexico-West Texas; Myron J. Ettus, Niagara Frontier; James S. Arnold, Northern California; C. R. Cripliver, North Texas; Norman L. Baker, Pacific Northwest; C. M. Reinhardt, St. Louis; Charles J. Swet, San Diego; Eric Burgess, Southern California; Milton Dowell, Southern Ohio; Leonard Berlin, England; A. R. Shalders, Australia.

Advertising and Promotion Manager
WILLIAM CHENOWETH

Advertising Representatives
D. C. EMERY & ASSOCIATES,
155 East 42nd St., New York, N. Y.
Telephone: Yukon 6-6855
JAMES C. GALLOWAY & CO.,
6535 Wilshire Blvd., Los Angeles, Calif.
Telephone: Olive 3-3223
JIM SUMMERS & ASSOCIATES,
35 E. Wacker Drive, Chicago, Ill.
Telephone: Andover 3-1154
R. F. PICKRELL & ASSOCIATES,
318 Stephenson Bldg., Detroit, Mich.
Telephone: Trinity 1-0790
HAROLD SHORT, Holt Road, Andover, Mass., Telephone: Andover 2212
RODNEY W. CRAMER, 852 Leader Bldg., Cleveland, Ohio., Telephone: Main 1-9357

ASTRONAUTICS is published monthly by the American Rocket Society, Inc., and the American Interplanetary Society at 20th & Northampton Sts., Easton, Pa., U.S.A. Editorial offices: 500 Fifth Ave., New York 36, N. Y. Price: $9.00 a year; $9.50 for foreign subscriptions; single copies $1.00. Application pending for second-class entry at the Post Office at Easton, Pa. © Copyright 1957 by the American Rocket Society. Notice of change of address should be sent to Secretary, ARS, at least 30 days prior to publication. Opinions expressed herein are the authors' and do not necessarily reflect those of the Editors or of the Society.

EDITORIAL

33 Tomorrow Is Today . . . . . *Robert C. Truax*

FEATURES

34 ICBM: Giant Step into Space . . . . . *Simon Ramo*
42 An Industry Leader Looks at the Future . . . . . *Dan A. Kimball*
45 Propellants for Tomorrow's Rockets . . . . . *Fritz Zwicky*

ASTRONAUTICS REPORT

50 Engineering for the High Temperature Age of Flight . . . . . *Frederick L. Bagby and Associates*

NEWS

54 Toward Improved Missile Communications . . . . . *Robert C. Toth*
56 On Top of the World . . . . . *Col. John P. Stapp*

SPECIAL IGY REPORT

60 Who's Who in the IGY
62 Rundown on the Vanguard Vehicle
64 IGY Sounds Off . . . . . *Michael L. Yaffee*
66 The Vanguard Instrument Package . . . . . *Herbert Friedman*
70 'Brain' to Map Satellite Orbit
71 Geodesy Comes of Age with Vanguard . . . . . *John A. O'Keefe*

DEPARTMENTS

7 At Press Time
8 On the Calendar
10 Capital Wire
12 In Print
16 Patents
18 People in the News
28 Government Contracts
74 Missile Market
76 ARS News
114 New Products
126 Index to Advertisers

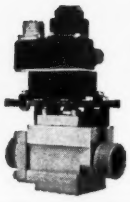
TECHNOLOGY

787
A9
V.2-3

The common denominator of all Hydromatics missile valves

MOTOR OPERATED CONTROL VALVES

Sizes from ¼" to 1½". Ports per MS33514, AND10050, AND10056, or special configurations. DC motor with automatic current shut-off. Response times from 0.8 to 3.0 sec. Remote light position indication. Positive locking design.



*Proven reliability for missile operation.

MULTI-LINE PROPELLANT VALVES

Sizes from ¼" to 4" in any combination. Motor or pressure operated. Actuating pressures from 200 to 3000 psi. Mechanically linked, simultaneous control of fuel and oxidizer lines. Available with adjustable fuel-oxidizer lead.

*Proven reliability for missile operation.

PRESSURE OPERATED CONTROL VALVES

Sizes from ¼" to 8". Ports per MS33514, AND10050, AND10056, and ASA flanges. Fast response rates from 20 milliseconds full stroke. Single or double acting actuators. Actuating pressures from 200 to 3000 psi. Remote light position indication.

*Proven reliability for missile operation.

RELIABILITY

PROVEN TEMPERATURE RELIABILITY
−320°F to +250°F

PROVEN PRESSURE RELIABILITY
0 to 3000 psi

PROVEN MEDIA RELIABILITY
For all liquids and gases
CRYOGENICS
CORROSIVE
GENERAL SERVICE

PROVEN FLO BALL RELIABILITY

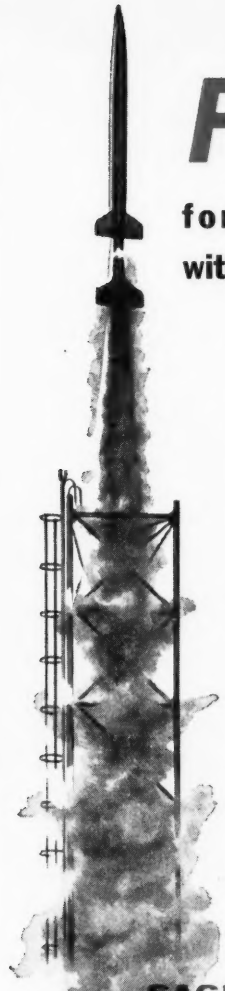
FLO-BALL, Hydromatics' revolutionary valve design that solves flow control problems previously considered impossible. Built-in design features establish new standards of reliability and performance—Straight-thru unobstructed flow path for absolute minimum pressure drop. Flow throttling characteristics linear with valve position. Self-wiping, self-lapping action of ball and seat insures long life and bubble-tight sealing.

Hydromatics serves the aircraft and missile industry by creating new concepts in valve design and performance.
For airborne or ground application, for standard or custom design—
check first with Hydromatics.

40 Factory Street
Cedar Grove, N. J.
PILGRIM 6-7044

Hydromatics, Inc.

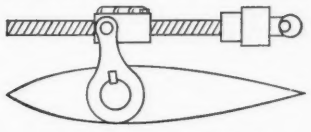
Cedar Grove, N. J.



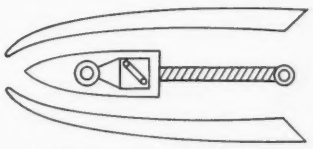
FAIL-SAFE ACTUATION

for guidance and control in difficult environments with SAGINAW b/b SCREWS and b/b SPLINES

TYPICAL APPLICATIONS

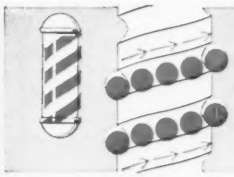


Control surface actuators

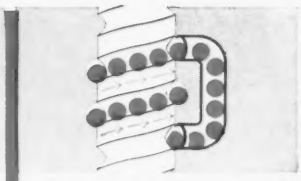


Nose cone positioners

Evelon positioners • Afterburner controls • Speed brake actuators • Rocket engine displacement actuators • Clamping mechanisms for missile boosters • Fuel controls (3-dimensional cams) • Black box tuning devices—telemetering and guidance systems • Antenna coupler tuning mechanisms



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅕ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

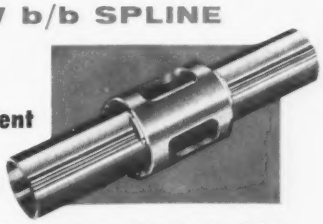
6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

SAGINAW b/b SCREW

Custom machined and commercial rolled thread types—built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter

SAGINAW b/b SPLINE

Averages 40 times lower friction coefficient than sliding splines



Radically increases efficiency of transmitting or restraining high torque loads; built from 3 inches to 10 feet long, ⅜ to 6 inches diameter

SEND TODAY FOR FREE 36-PAGE ENGINEERING DATA BOOK . . .

or see our section in Sweet's Product Design File

Outstanding opportunities for qualified engineers

Saginaw ball bearing Screws and Splines

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 10AA, Saginaw, Michigan

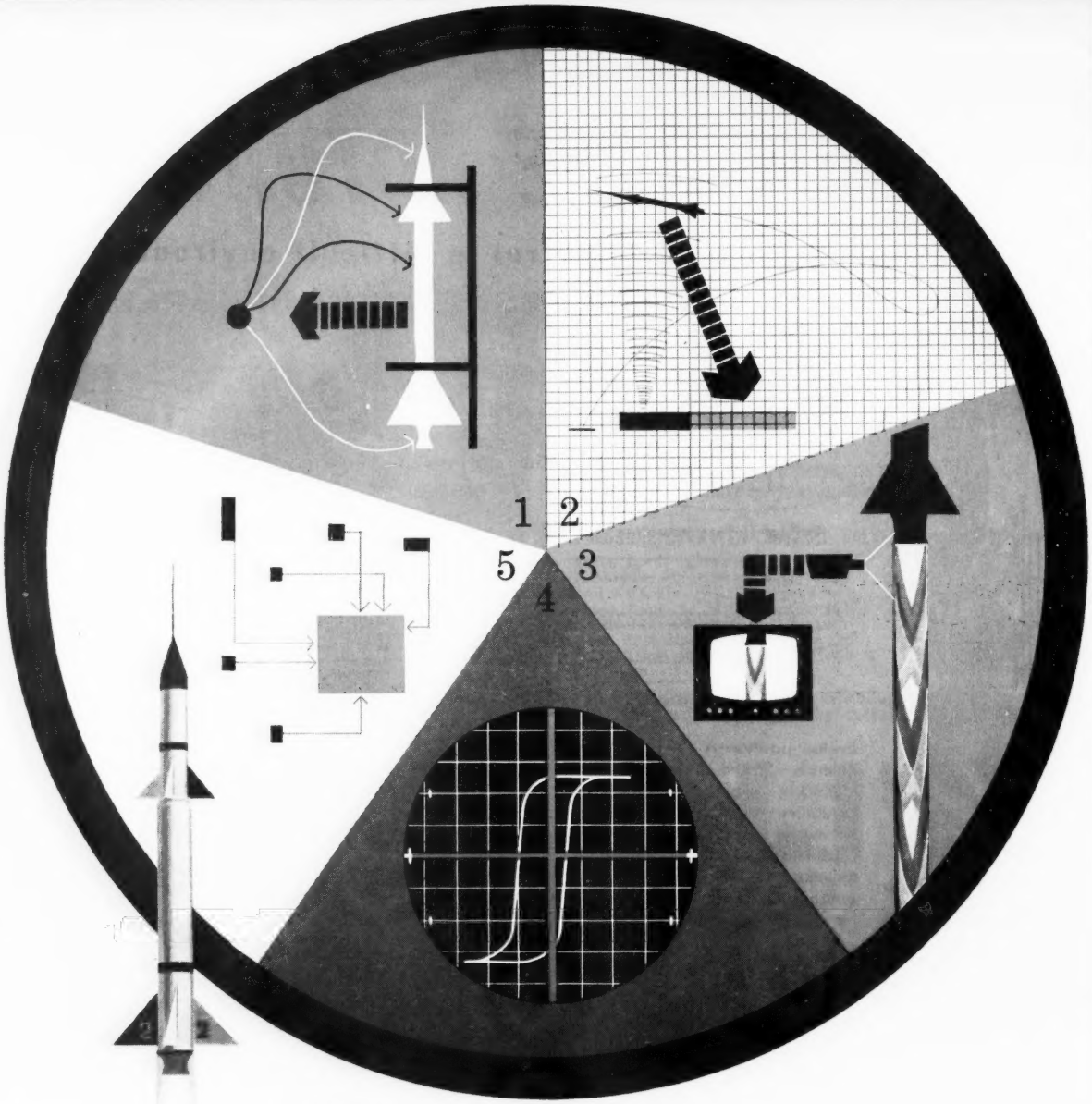
Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME_____

COMPANY_____ TITLE_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____



ENGINEERS & TECHNICIANS

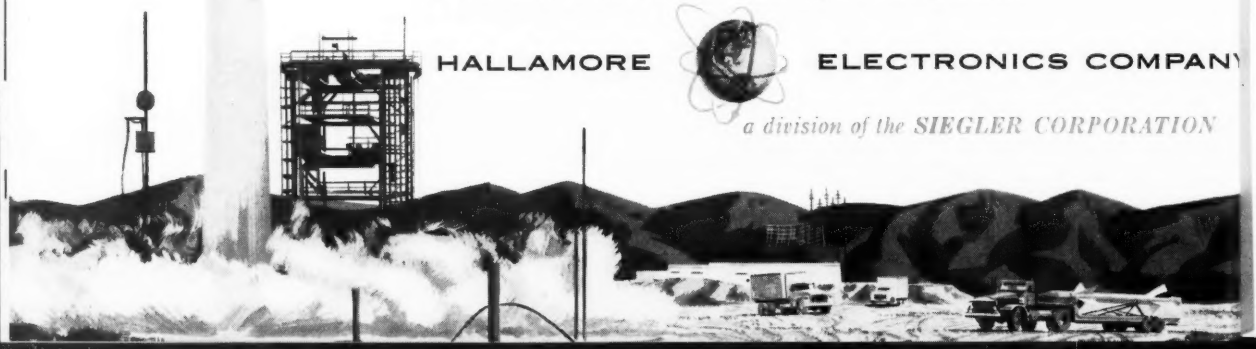
For ideal working conditions with a dynamic, creative organization, send resumé to Chief Engineer....
8352 Brookhurst, Anaheim, Calif.

Hallamore's doing it now

Hallamore Electronics Company is currently working in 5 segments of the electroni field essential to the success of our national defense program: 1. Missile and aircraft test and ground support equipment (development through installation); 2. Missile instrumentation and guidance systems; 3. Advanced communications systems; 4. Magnetic amplifier products (autopilots, power supplies, etc.); 5. Electronic components. The Hallamore team, approximately 1/3 engineering personnel, passed the 1150 figure in March of 1957 at its fast expanding new Anaheim, California facility...a dynamic, *do it now* organization.

HALLAMORE ELECTRONICS COMPANY

a division of the SIEGLER CORPORATION



at press time

Up-to-the-minute news about the rocket, guided missile and jet propulsion fields

ARMED FORCES

• Long-range AF planning for the next decade or two is the aim at a high-powered meeting of top scientists, including missile men, at Woods Hole, Mass., this summer. Director of the program is Theodore von Kármán; sponsor is the National Academy of Sciences, under an AF contract. Expected to attend are Edward Teller, George Gamow, Alfred Eggers, H. L. Dryden, George Gerard and many others.

• AF protests against news blackouts on missile tests have been directed to Congressmen considering defense information policies. Complaints are centered on DOD directive forbidding any disclosures about such tests except facts that missile was fired and whether any casualties occurred.

• A published report that the Army was going ahead with development of both a 2000-mile ballistic missile and a smaller 750-mile missile was firmly denied by a high DOD official. "There's nothing to it, especially in the upper range category," he commented. He recalled that the Wilson directive defining missions gave the Army the option of carrying out feasibility studies beyond the 200-mile limit. "This is what is being done," he noted.

• First U. S. submarine with a missile hanger incorporated in the hull was launched at Mare Island, Calif. Named "Grayback," the diesel-powered craft has Regulus capabilities. Two Navy missile subs are now operational and two more are under construction, one of them nuclear-powered.

• OSR will attempt to launch a rocket from a balloon "sky platform," following closely a proposal presented at an ARS meeting two years ago by NRL's Kurt Stehling. AF expects the rocket, to be fired from a General Mills balloon at more than 100,000 ft, to reach a record altitude.

MISSILES

• AF is junking the Navaho program after spending $500 million on its development since 1946. Official reason was budget cuts, although two unsuccessful tests and recent Snark production contract may also have been factors in the decision. Navaho had been under contract with North American Aviation.

• U. S. approaches to Russia at the London disarmament talks reportedly envisage possible ban on "outer-space guided missiles" as meeting progresses. Basic snags on nuclear weapons have precluded serious missile discussions to date. Although DOD officials have offered assurances that no proposals on delivery systems have been discussed, a Senate disarmament subcommittee is interested in how any such agreement would affect ICBM-IRBM development.

• Firestreak, Britain's infrared-homing air-to-air missile, does not function well in clouds or rain, its manufacturer acknowledges. De Havilland Aircraft, confirming reports to that effect, claims the weapon was designed to function in the moistureless stratosphere.

BUDGET

• Defense Dept. budget was expected to conform to Senate bill allotting $34.5 billion. Though a total of $1.6 billion less than asked, $1.3 billion of the cut was made on paper by bookkeeping transfers. House action had slashed still another $1 billion from original Administration request of $36.1 billion, but Senate prevailed in restoring all but $0.3 billion of the real money items. Broken down by services, Army gets $7.4 billion, Navy $10 billion, Air Force $16.4 billion, with the remaining $0.7 billion for DOD activities.

on the calendar

1957	
Aug. 6–10	Naval Aviation Meeting, IAS, San Diego, Calif.
Aug. 11–15	Heat Transfer Conference, ASME, Penn State University.
Aug. 20–23	Western Electronic Show and Convention, San Francisco, Calif.
Aug. 25–28	**American Rocket Society—Northwestern Technological Institute Gas Dynamics Symposium on Transport Properties, Northwestern University, Evanston, Ill.**
Sept. 8–13	National Meeting, ACS, New York, N. Y.
Sept. 15–18	Regional Meeting, AIChE, Baltimore, Md.
Sept. 23–25	Fall Meeting, ASME, Hartford, Conn.
Oct. 1–5	Aeronautic Meeting, Aircraft Production Forum and Engineering Display, SAE, Los Angeles, Calif.
Oct. 7–9	National Electronics Conference, Chicago, Ill.
Oct. 7–12	**Eighth International Astronautics Congress, International Astronautical Federation, Barcelona, Spain.**
Oct. 10–12	Fuels Conference, ASME, Quebec City, Quebec, Can.
Oct. 21–23	Power Conference, ASME, Allentown, Pa.
Oct. 28–29	East Coast Aeronautics and Navigation Conference, IRE, Baltimore, Md.
Oct. 30–31	Annual Technical Meeting, Electronic Devices Group, IRE, Washington, D. C.
Nov. 6–8	Fuels and Lubricants Meeting, SAE, Cleveland, Ohio.
Nov. 11–13	Instrumentation Conference and Exhibit, IRE, Atlanta, Ga.
Nov. 25–26	Joint Meeting, IAS and Canadian Aeronautical Institute, Montreal, Quebec, Can.
Dec. 1–6	Annual Meeting, ASME, New York, N. Y.
Dec. 2–5	**American Rocket Society 12th Annual Meeting, Hotel Statler, New York, N. Y.**
Dec. 6–7	**American Rocket Society Eastern Regional Student Conference, Hotel Statler, New York, N. Y.**
Dec. 8–11	Annual Meeting, AIChE, Chicago, Ill.
Dec. 17	Wright Brothers Lecture, IAS, Washington, D. C.
Dec. 26–31	Annual Meeting, American Assn. for the Advancement of Science, Indianapolis, Ind.
1958	
March 17–20	**American Rocket Society—ASME Aviation Div. Conference, Statler-Hilton Hotel, Dallas, Tex.**

Budget

• Earlier, NACA got $106 million of the $118 million it had asked, a hike of almost $30 million over 1957. Operations will take $75 million, equipment and construction the remaining $35 million (against $62 million and $14 million respectively in fiscal 1957).

• Economy will be practiced by executive agencies to keep spending at a minimum, in accordance with a budget directive issued at the President's request. Departments have been urged to keep "rates of commitment, obligations and expenditures" for fiscal 1958 at or below fiscal 1957. Exceptions require a written explanation.

IGY

• U. S. IGY rocket firings at Fort Churchill on July 4 (see page 64) may have been the only ones in the world on the first Regular World Day of the International Geophysical Year. While several other nations, including Great Britain, France and Japan, have indicated they will fire sounding rockets in the next 18 months, their programs are not expected to be ready before fall. Russia will also conduct IGY firings but has given no timetable.

• Soviet Academy of Sciences President Nesmeyanov has written that the first Russian satellite would be launched "literally within the next few months."

Foreign

• Authoritative reports from Washington indicate the Russians have successfully tested a ballistic missile with a 1200-mile range. Despite this, the Russians are said to be behind the U. S. in ICBM-IRBM development work and concentrating instead on weapons with ranges up to 600 miles, along the lines of German World War II efforts.

Industry

• Government arsenals should get out of the development and production of missiles, the Aircraft Industries Assn. argues. AIA President Orval A. Cook, hitting back at charges made at the court-martial of the Army's Col. John Nickerson, claimed the government "has never been successful as a producer of aircraft" and there was no reason to assume its missile efforts would be any better. Such functions "belong to industry," he contended.

• Borane high energy fuels have moved into "semi-commercial" production at Olin Mathieson's Niagara Falls complex. AF will get the boron-based materials, called HEF-2 and HEF-3 by the company. HEF-4 is reported by the company to be ready to be phased into production when needed. O-M has also begun construction of a new $36 million AF-sponsored plant near its Niagara Falls complex.

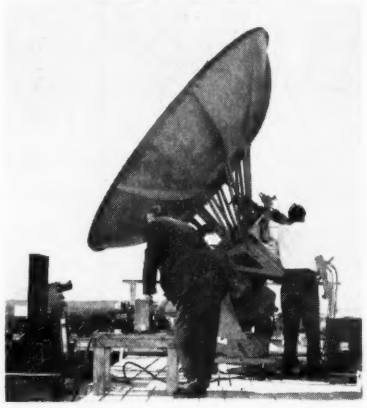
• Goose project has resulted in an expansion of the Hagerstown, Md., facilities of Fairchild Engine and Airplane Corp.

• Aerojet-General has established a new astronautics research laboratory to carry on research in three principal areas—propulsion, astrophysical chemistry and materials. The laboratory will be under the direction of Y. C. Lee, director of research, and Milton Farber, assistant director of research, Liquid Engine Div.

• Reaction Motors has created a separate applications engineering department for solid rocket propellant powerplants, responsible for the development of new business in the field.

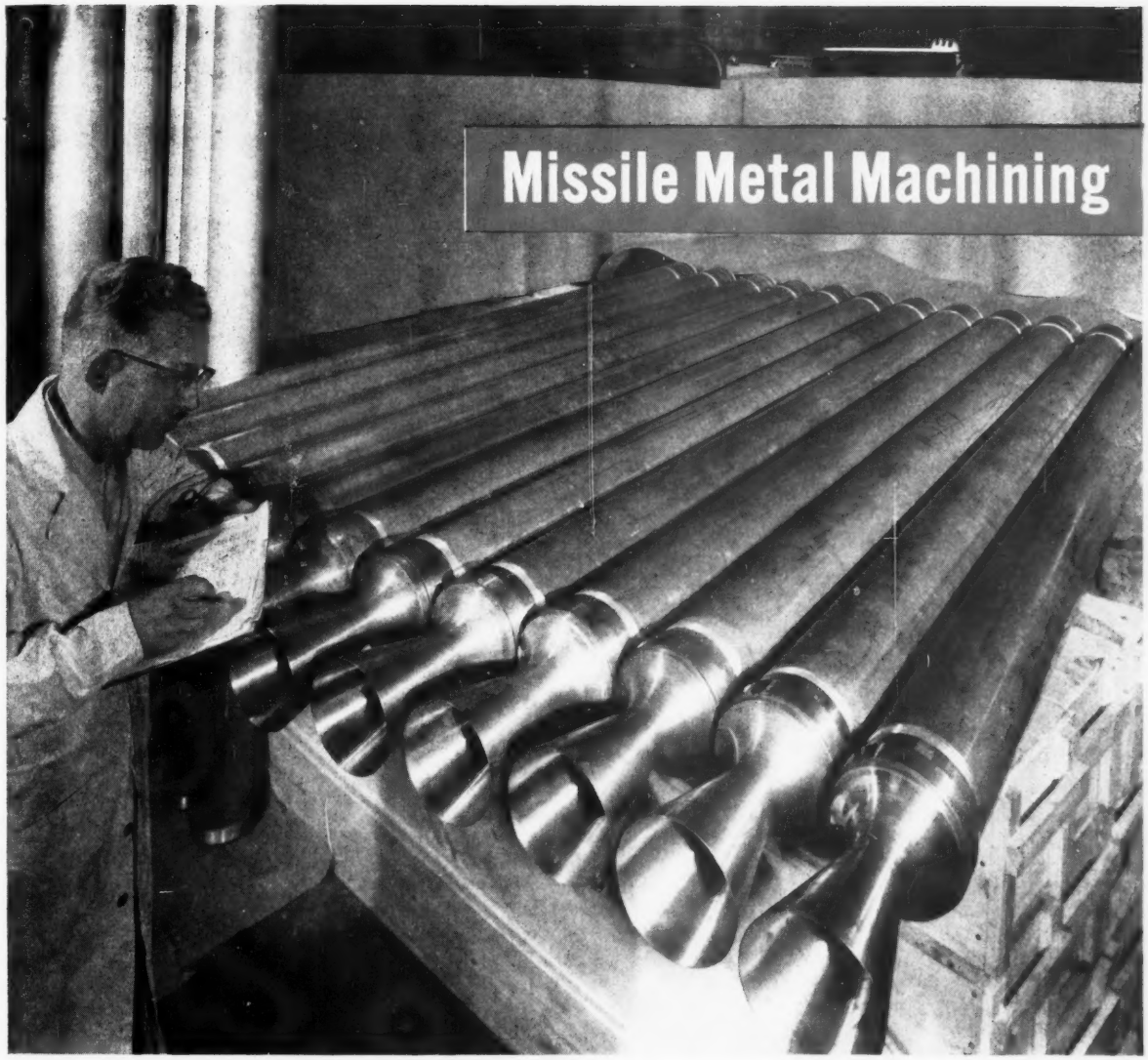
Materials

• New York University's third annual titanium lecture program will be held Sept. 9–13. The session on Sept. 11 will be devoted to a discussion of elevated temperature properties and applications, and will cover use of titanium in missiles and aircraft.



Sun-Gazing

Naval Research Laboratory scientists make adjustments to radio telescope used to record solar activity during International Geophysical Year.



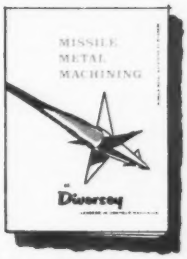
BUILT GOOD–
LIKE A ROCKET SHOULD

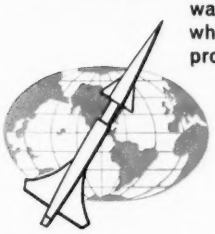
High altitude research rocket motors built by Diversey in their final check out before shipping. Another example of how Diversey Engineering integrates the finest and most advanced contour machining techniques into the building of complete rocket motors.

We make everything from special components to complete rockets. In the area of missilery hardware Diversey knows and uses modern techniques that would startle you.

You have the largest facilities and the most modern equipment for your hardware problems at Diversey Engineering. In this field we know what works and what won't. Contact us on your rocket motor problems.

SEND FOR FREE BOOKLET





LEADERS IN CONTOUR MACHINING

Diversey ENGINEERING COMPANY

10550 WEST ANDERSON PLACE
FRANKLIN PARK, ILLINOIS • *A Suburb of Chicago*

FROM NOSE TO NOZZLE, FROM FIN TO FIN, CONTOUR TURNED PARTS—WITH PRECISION BUILT IN

capital wire

News highlights from Washington

No U. S. tracking "fence" over which the Russian satellite would pass on its polar orbit is contemplated, according to Richard W. Porter, head of the technical panel for the earth satellite, USNC-IGY, and former ARS president. "We have no assurance what their orbits will be," he complained to Academy of Science sessions that kicked off IGY. We would give "eager consideration" to any Russian request for help in tracking their "moon," he noted, but no such help has been asked.

Some signals from the Soviet satellites will undoubtedly be picked up by the fence of stations erected for the U. S. satellites. Better reception would result if antennas were turned perpendicular to the Russian path, but Dr. Porter doubted even this modification.

•

Last of a dozen satellite optical tracking stations will be operating before March 15, with half of those ready by January. The first try at putting the tiny ball in the sky should not have to wait for the last station, scientists said, suggesting that the first satellite could be placed in orbit anytime after the first of the year without losing too much data because of the absent stations. Enforcing this are public assurances that all Minitrack facilities will be operating by that time.

•

A look at the future was given manufacturers here by AF officials. Missile makers went away happy, aircraft makers understandably glum at predictions that, over the next few years, with a $7 billion AF budget:

Missile slice will zoom to $2.3 billion, 460 per cent over fiscal 1956.

Aircraft will be cut in half to $2 billion.

Electronics will double to $1.3 billion.

Engine procurement will dip 33 per cent to $1 billion, with turbojets hardest hit but stepped up ramjet and rocket buying softening the over-all blow.

In other areas, AF brass acknowledged that aircraft firms will continue to be prime contractors for missile systems "even though some electronic companies have, with good justification, argued that they should be prime . . ."

•

"Rapid, spectacular growth of the ballistic missile program during Fiscal 1957" was blamed by Air Sec. Douglas for overspending in his department. "Payment on the program (during Fiscal 1957) . . . substantially doubled as against the estimate for that program when the 1957 budget was formulated."

•

"Cone defense" against ballistic missiles remains in vogue here. This presumes that missiles from a well-spotted enemy launching site must pass through a relatively small conic section of upper space, i.e., that section which includes trajectories to all probable targets. With sufficient warning (and pinpoint location of the launching site), the section can be saturated at some optimum point with nuclear explosions, thus vaporizing any missile as it comes through—theoretically.

•

Vanguard's third test shot is upcoming around the first of this month. Designated the TV-2 (behind Vikings TV-0 and TV-1), this will be the first actual prototype of the satellite launching vehicle, standing a full 72 ft and weighing 11 tons. Only the first stage will be real, the others simulated. Although the second-stage engine (from Aerojet-General) was accepted in April, it will wait for TV-3 to be flight tested. No date has been set for that trial as yet.

•

New missile czar William M. Holaday, besides overseeing all missile programs, including Vanguard, has taken on the staggering assignment of weeding out the chaff from all the projects of the three services. After studying every missile now being researched or developed, he will have the unpopular job of picking those to be put into operation. Some pet items are likely to find themselves shelved before this attempt at a truly unified missile program is finished.

Wherever possible, one missile for each range will be the Pentagon goal. One official said that by the fall a close look at the ballistic missile competition will have to be taken, obviously in the interest of economy. This summer's tests of the Atlas ICBM may tell the story on which of the big "birds" gets dropped.

•

Convair's B-58 Hustler will reportedly get a new guided air-to-ground missile to be carried under its airframe. Either an existing weapon will be modified for the bomber or, more likely, an entirely new missile will be developed.

•

Sen. Henry M. Jackson (D-Wash.) has been beating the drums for more money and effort for seagoing missiles and their launching craft, arguing that mobility would markedly lower the chance of the base being discovered (and destroyed) before getting off a shot. He emphasized that this should not slow down development of land-based IRBM's and ICBM's, however, and did not anticipate the end of the manned bomber. But the influential Senator, who chairs the powerful military applications subcommittee of the Joint Congressional Committee on Atomic Energy, strongly advocated a more balanced missile force "to cover every good bet." Polaris, the Navy's IRBM, is being developed on "a far smaller scale and with a far longer timetable," he complained.

Polaris is said to be at least a year away from flight testing.

•

A Guided Missile Force, presumably to take over all of the larger missiles from design through production and include personnel to fire the weapons, has been batting around Congressional cloak rooms for some time. Spurred by the clamor to cut government expenses, one member of a House appropriations subcommittee recently suggested such a force but when queried explained it was just his way of soliciting the opinions of colleagues. There appeared to be no enthusiasm for the suggestion, however.

•

Anti-missile missiles and antiaircraft missiles seem to have been interchanged in recent news reports emanating here. Lt. Gen. James M. Gavin, the Army's R&D chief, promised 100 per cent defense against aircraft, not ballistic missiles, according to his staff.

The general did refer to an anti-missile missile in response to questioning at a Senate appropriations committee hearing, soon after referred to possible aircraft attack, which may account for the apparent telescoping of answers. He said the much-sought-after defense weapon would emerge from the Nike family of "point defense" weapons. He also revealed that "several" successful test firings of Army's Jupiter IRBM have been made. The Air Force is also working on anti-ballistic missile programs.

ENGINEERS · SCIENTISTS

"We're developing the Atlas ICBM ...giant step toward Outer Space!"

DR. HANS R. FRIEDRICH
Assistant Chief Engineer – Development of CONVAIR-*ASTRONAUTICS*, received his Ph.D. at the University of Leipzig, and was the co-developer, with Dr. Wernher von-Braun, of the famous V-2 rocket. He is responsible for directing the research and technical development of the Atlas ICBM.

"The Atlas Intercontinental Ballistic Missile, now being designed and developed by CONVAIR-*ASTRONAUTICS*, will be, for a time during its flight, a true space vehicle. At hypersonic speeds, it will travel hundreds of miles beyond the earth's atmosphere.

"That's why our top theoretical scientists here at CONVAIR-*ASTRONAUTICS* are exploring every implication of flight into space. Even now these men are thinking in terms of multi-stage rocketry, re-entry, solar propulsion and cosmic dust bombardment. Other teams of our engineers and technicians are engaged in the practical application of this new science, Astronautics.

"Our first job here at CONVAIR-*ASTRONAUTICS*, of course, is to make the Atlas ICBM operative, for we are aware that this is a top priority weapon. You – as an engineer – can appreciate the stimulating atmosphere generated by a project so vital to America's defense.

"As a graduate engineer or scientist with an aptitude for creative thinking, your future is with CONVAIR-*ASTRONAUTICS*. Here you will associate with the leaders in this advanced field – work in our new $40,000,000 facility. You will see and feel the kind of achievement that means personal progress. And you will enjoy living at its best in beautiful, smog-free San Diego.

"For your future's sake, write today to: Mr. G. N. McMillan, Engineering Personnel, Dept. 78-J.

CONVAIR
ASTRONAUTICS

3302 Pacific Highway, San Diego, California

CONVAIR IS A DIVISION OF GENERAL DYNAMICS CORPORATION

in print

Man Into Space, by Hermann Oberth, translated by G. P. H. De Freyville, introduction by Wilhelm Meyers-Cord. Harper and Brothers, New York, 1957, xiv + 226 pp., including mathematical appendix. $4.50.

Reviewed by COL. JOHN P. STAPP
Aero Medical Field Laboratory
Holloman AFB

Somewhat like the Romantic movement in music during the last century, we have a Romantic movement in physics today. The comparison is apt, because the great musical romantics—Beethoven, Brahms, Wagner and the rest—were not only daring and unconventional in creative projection of the imagination, but were technically superb. They had the audacity to dare imperfection of innovation in order to explore new areas of musical expression. This indomitable enthusiasm for extending intellectual boundaries sets the pace for later methodical realism of accomplishment.

The Romantic movement in physics also has its great names—Oberth, von Braun, Strughold—all superbly trained scientists, generating prodigious projections of the scientific imagination to visualize the conquest of space through applied physics, physiology and engineering. This requires a brave disregard of details in order to consider the awesome whole, a form of poetic license that can be extended to scientists looking beyond the known. I refuse to offer criticism for distortions of details with which I may be more familiar through experience, but I shudder a little when the terms "easy" and "simple" are bandied about where I would feel daring to say "possible" or "feasible."

However, if Hermann Oberth says that doing low temperature research on a space satellite is easy, who am I to question it? I am thoroughly in sympathy with the objective of a great teacher trying to kindle the enthusiasm of a class in his difficult subject by glamorizing and gloriously oversimplifying it. Hermann Oberth has written a beautiful example of unconventional thinking, full of stimulating suggestions very clearly expressed. It is worthy of careful reading by the young for inspiration, and by the old as a fishing expedition for ideas.

There is no place for disdain toward a magnificent conception just because there are flaws in the details. Time and inevitable development will see fulfillment of what is feasible and worthwhile in this book, just as his "By Rocket Into Interplanetary Space" is finding amazing fulfillment while Oberth lives to see it.

A glimpse of greatness tinges the last chapter of the book, wherein Hermann Oberth expresses a few philosophical and scientific ideals and hopes for mankind. In these, his title to being the pioneer of the Romantic movement of modern physics is indisputable, and a nobility of spirit akin to that of Beethoven is most evident. A truly remarkable man is revealed between the lines of this very personal scientific treatise.

Realities of Space Travel, edited by L. J. Carter, Putnam, London, 1957, 431 pp., including name and subject index. 35 *s.* net.

Reviewed by KRAFFT A. EHRICKE
Convair Div. of General Dynamics

In the international community of astronauts, there is general agreement that our British colleagues are in the forefront when it comes to analytical and conceptual treatment of space travel problems. They are organized in the British Interplanetary Society, which skillfully combines broad astronautical appeal (its membership is in excess of 3000) with high academic standards in its publications, the veteran *Journal* and the new *Spaceflight*. Ever since World War II, leading British and foreign experts in astronautics have contributed to the *Journal*. However, its limited circulation did not do justice to many excellent articles, and independent work was done elsewhere without reference to British contributions.

We therefore welcome particularly the new book, "Realities of Space Travel." Edited by L. J. Carter, the present BIS secretary, it contains 24 selected papers published during the past decade in the *Journal*. The majority of the authors are British, and represented among them are most of the leading personalities in British astronautical research, such as A. C. Clarke, A. V. Cleaver, K. W. Gatland, D. F. Lawden and L. R. Shepherd, to name only a few.

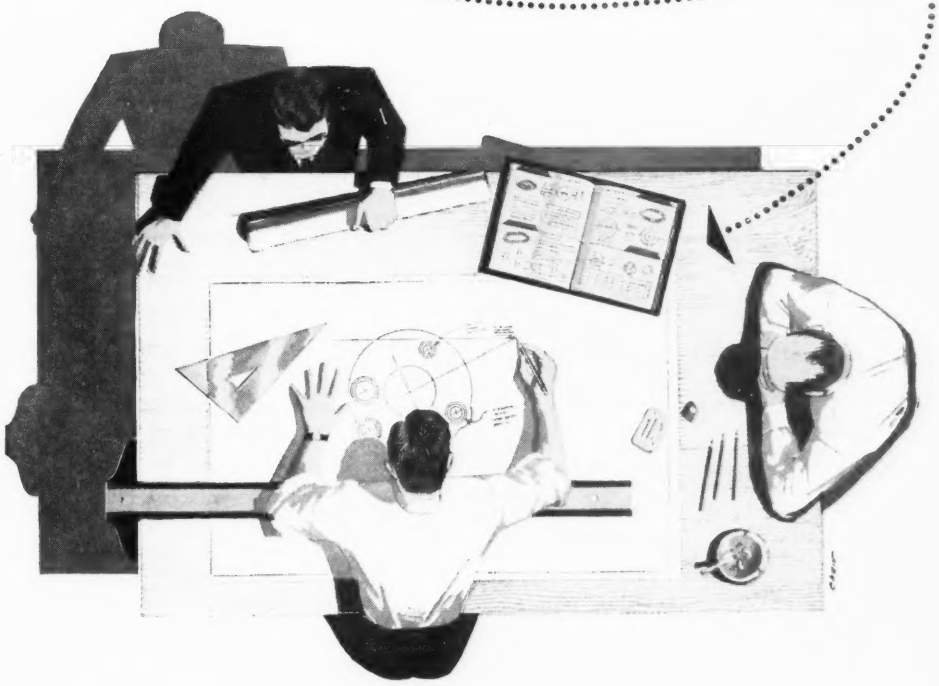
The book is divided into 11 chapters, 10 dealing with astronautical subject areas, the 11th being an appendix providing information about the BIS, and a list of astronautical and rocket societies. Chapter I, called *Introduction to Astronautics,* contains papers by Shepherd, Clarke and Cleaver on fundamentals in astronautical principles, space flight dynamics, rocket engines and propellants, mass ratios and the calculation of the take-off mass of rocket vehicles.

Chapter II, entitled *The Satellite Vehicle,* contains two classics, the article on "Minimum Satellite Vehicles" by Gatland, Kunesh and Dixon, in which the concept of a very small payload (and even zero payload) earth satellite was originally advanced, and S. F. Singer's article, "A Minimum Orbital Instrumented Satellite—Now," in which he suggested the MOUSE. The third paper in this chapter contains an excellent general analysis of the problem of descent of glide vehicles from orbits, by T. Nonweiler. The next chapter, entitled *Interplanetary Flight,* is made up of four articles, two dealing with propulsion problems, one with interplanetary flight operations and one with flight mechanics. W. Neat discusses limiting factors of chemical rocket motors, Shepherd and Cleaver analyze "The Atomic Rocket," H. Preston-Thomas discusses "Interorbital Transport Techniques," and D. F. Lawden, whose work in the field of space flight mechanics has gained him world recognition, concludes with a paper on "Determination of Minimal Orbits."

The fourth chapter deals with *Physical Factors in Space Flight* in two papers, one on "Meteor Hazards to Space Stations" by M. W. Ovenden, and the other on cosmic ray hazards, again written by Shepherd, one of the most versatile British scientific authors. Three papers are featured in Chapter V, *Biological Aspects of Space Flight,* two of which are by American authors, namely, Col. P. A. Campbell, writing on "Aeromedical and Biological Considerations of Fight Above the Atmosphere," and the other by N. J. Bowman, on "Food and Atmosphere Control Problems on Space Vehicles." A. E. Slater of the BIS reports on "Sensory Perceptions of the Weightless Condition."

In Chapter VI, *Targets for Tomorrow,* we find brief reviews of our knowledge about the moon and Mars (1954) in two papers, both by P. Moore, well known to readers of astronautical literature. Chapter VII, *Development of Astronautics,* contains only one paper, "A Programme for Achieving Interplanetary Flight," by A. V. Cleaver. This study, an outstanding example of balanced thinking, presents a mature, dispassionate approach to a much discussed problem. In the reviewer's opinion, Cleaver's paper should be studied carefully by those who wish to try their hand in space flight development analyses. (CONTINUED ON PAGE 14)

. . . good sealing begins here, too!



When the problem of sealing is a part of *design thinking* the whole design is bound to be better. This is especially true of *no-leakage* sealing. When your designs require sealing . . . from −400° to +1000° . . . why not call in one of our field men. One of the "O-seal" family*, may be the answer to save you time, money and effort.

*—the O-Seal family:
Lock-O-Seal®
Gask-O-Seal®
Stat-O-Seal®
Bolt-O-Seal®
Riv-O-Seal®
Banj-O-Seal®
Termin-O-Seal®

FRANKLIN C. WOLFE CO.

A DIVISION OF PARKER APPLIANCE COMPANY

"sealing design specialist"

Culver City, California

New Sounding Rockets in the Air

Fort Churchill—John W. Townsend Jr., in over-all charge of the Naval Research Laboratory Field Group at this IGY rocket site in northern Canada, discussed Navy plans for putting two new types of sounding rockets into the air soon.

The rockets are the Arcon and the Iris. Both are solid propellant vehicles produced by Atlantic Research Corp. Iris, larger of the two, is said to be capable of carrying more than a 100-lb payload. With the progress now being made in miniaturization of instruments, the Navy figures that it will soon be able to shoot the same type and order of experiments in the Iris as are now being carried out with Aerobees. At the same time, cost of the Iris is expected to run about one-third of that of the Aerobee.

Moreover, since the Iris is a solid propellant rocket, it will ease considerably logistic, storage and fueling problems created by the red fuming nitric acid, aniline and helium required by the Aerobees. On the other hand, the use of solid propellant rockets could create a problem in range safety. Unlike operation of liquid propellant rockets, wherein the vehicle can be brought down to a predetermined impact point at any moment it appears to be going outside the range, the solids would have to be destroyed in the air. And because of the unpredictable path of the resultant debris and danger, destruct time would probably be correspondingly earlier for the solid.

According to Townsend, the Naval Research Laboratory has already purchased seven Iris rockets and, in conjunction with the Signal Corps Engineering Laboratory, seven Arcons. First firings are scheduled to take place in January 1958.

First to go will be four Arcons, two from NRL and two from SCEL. One from each group will be unboosted; the other two will have small anti-wind dispersion boosters. Fifth and sixth rockets will be SCEL Arcons with Nike boosters and will be fired sometime in March or April. All six Arcons will be instrumented principally for rocket performance, in a joint effort by SCEL and NRL. The next rocket, another SCEL Arcon, will be instrumented for upper air research, probably in the Signal Corps grenade experiment.

The seven Iris rockets will be fired starting sometime in June 1958. All Iris rockets, says Townsend, will probably function as test vehicles. And except for the two Nike-Arcons, all the new rockets will be fired from NRL's mobile launcher at White Sands, N. Mex.

Aerobee-maker Aerojet-General Corp., of course, is not standing pat with its present sounding vehicles. The company reports that it has a significantly improved version under development. Temporarily tagged Super Aerobee, the liquid propelled rocket is reportedly entering the final design phase.

Slightly larger in diameter than the current models, Super Aerobee will pack in more and probably different propellants. Compared to the latest version of the Aerobee-Hi, generally considered to have a practical upper limit of about 200 miles, the new Aerobee is expected to reach altitudes of approximately 400 miles. This could make the vehicle of value to all upper air rocket researchers. The Air Force Cambridge Research Center has reportedly already expressed an interest in the new Super Aerobee.—**M.Y.**

In Print

(CONTINUED FROM PAGE 12)

The editor, L. J. Carter, presents well-written surveys of the U. S. Naval Test Station at Inyokern and of the Anglo-Australian Rocket Testing Range at Woomera in Chapter VIII, *Establishments and Testing Stations*. Chapter IX, *History of Astronautics*, contains a vividly written account of "European Rocketry after World War I" by Walter Dornberger, a man who played a leading part in making rocket history during this period. Finally, Dr. Shepherd looks far ahead in Chapter X, *The Distant Future*, in the course of a broad scientific study on "Interstellar Flight."

Except for guidance and communication, no major field of the astronautical sciences remains untouched. Occasional footnotes inform the reader of important new developments or discoveries since the articles were written, thereby bringing the book well up to date. There have been a number of other good articles in the *Journal* which one might wish to have seen incorporated in the book. However, certain limitations are obviously unavoidable, since the book already contains 431 pages of excellent papers.

The editor must be credited with a difficult job well done by a judicious and well-balanced selection of papers, and by the inclusion of 23 excellent photos, showing Peenemünde test stands, high altitude rockets, a photographic portrait of the Southwest U. S. from 100 miles altitude, mice floating without weight in the Aerobee, film strips of Col. Stapp going through a 22 g deceleration test at Holloman, and the craters of the moon.

This book is a very fine contribution to scientific astronautical literature. It can be recommended unreservedly to old hands, as well as to newcomers in the field of the astronautical sciences.

Book Notes

ARS members may find "The Frozen Year" (Ballantine Books, $2.75; paper bound, 35 cents), a science-fiction novel by James Blish, of interest not so much as a work of fiction as for its frequent favorable allusions to the Society.

In the course of his story about an IGY expedition to the North Pole in 1958 which is seeking meteoritic evidence that the asteroids were once a life-bearing planet, Blish refers to such ARS stalwarts of the past as Larry Manning and Ed Pendray, mentions Joseph Kaplan and Fred Whipple, provides a capsule portrait of a thinly disguised Willy Ley, and has some harsh things to say about press treatment of early ARS rocket firings while praising the Society's role in bringing about Project Vanguard.

Add to this a good description of satellite tracking at the Pole, a dissection of the role of industry in scientific expeditions and an analysis of science writing, and you wind up with an enjoyable book. —**I.H.**

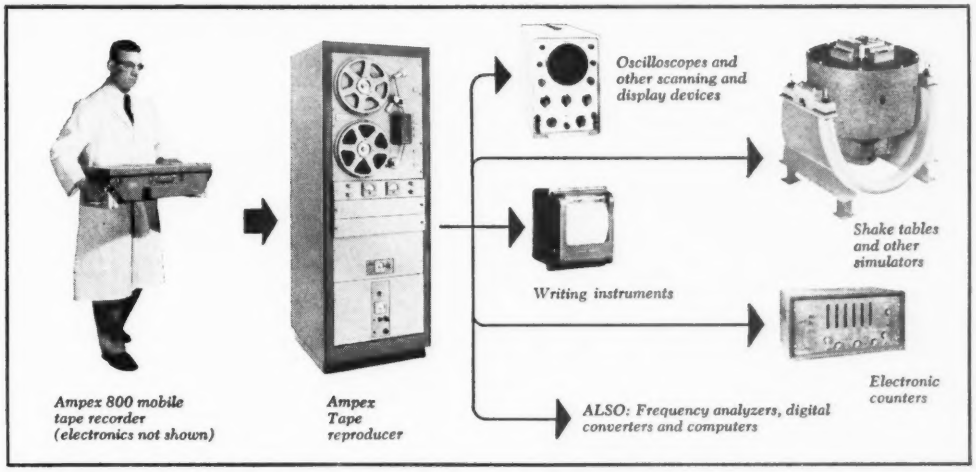
Nose Cone Contract for Avco

The Air Force announced last month that Avco Mfg. Co. has received a $111-million contract award for development of a nose cone for the Titan ICBM.

How to take an entire laboratory for a ride

Get complete mobile data despite shock and limits of space

This is the easy way – no such blue-sky dream as a shock-mounted, air-conditioned brick building on wings or wheels. The earthbound laboratory has a "double" that rides on airplanes, vehicles or ships or goes to location by manpower, muleback or dolly. The secret . . . an Ampex 800 mobile tape recorder which simultaneously gathers data for the laboratory's writing, viewing, simulating and computing instruments. Despite adverse environment, Ampex 800s closely match precision and versatility of laboratory tape recorders.


Oscilloscopes and other scanning and display devices
Shake tables and other simulators
Writing instruments
Electronic counters
Ampex 800 mobile tape recorder (electronics not shown)
Ampex Tape reproducer
ALSO: Frequency analyzers, digital converters and computers

Only this mobile tape recorder and its associated equipment undergo the hazards and space limitations of the mobile test situation.

Reproduction of the tape recreates the original transducer voltage patterns, providing every other laboratory instrument with the same input it would have received if it too had been carried on the test. Data slowdown, speed-up, filtering, etc. can be used.

Ampex 800 tape transport, showing small size and ease of handling. This is the largest of the recorder components.

AIRBORNE APPLICATIONS

Ampex 800s are widely used for environmental data, radio signals, radiation information, weapon countermeasures, flight parameters, etc.

At one airforce facility, the Ampex 800 rides in one aircraft to record telemetered signals from another (unmanned). Altitude greatly extends the horizon and tracking distance over which line-of-sight telemetered signals can be received.

Aircraft companies are tape recording vibrations, sounds, and other data far outside the range of other recording techniques. And in one major company's flight-test program, 420 channels of data are multiplexed onto a one-inch tape.

GROUND, SHIPBOARD AND VEHICLE USE

The Ampex 800 is light and rugged, withstands handling and sets up quickly and easily. A research group studying earth-transmitted shock waves carries the Ampex 800 right to locations next to railroad tracks, airfields, highways and other areas of interest. An oil company uses a truck-mounted 800 to log oilwells in the fields.

The equipment stands shock, vibration and noise. In a shipboard installation, the Ampex 800 gathers data on closeby underwater explosions, enduring shocks transmitted through the ship. At an eastern jet-engine test facility, dolly-mounted Ampex 800s are wheeled out to the cells and get accurate data in an area of intense noise.

Do you have a mobile data acquisition problem on which we can help? Or would you like this tape-recording series mailed to you direct? For either request, write Dept. AA-6.

INSTRUMENTATION DIVISION
AMPEX CORPORATION
FIRST IN MAGNETIC TAPE INSTRUMENTATION
934 CHARTER STREET · REDWOOD CITY, CALIFORNIA

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

MAGNETIC TAPE APPLICATIONS BY AMPEX

PAGE 6

from the patent office

BY GEORGE F. McLAUGHLIN

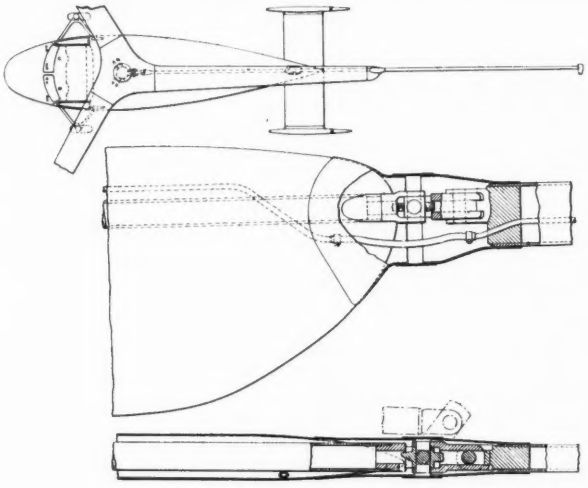
Helicopter Efficiency Increased by Extending Jets from Rotor Blade Tips

In rotative winged aircraft incorporating a sustaining rotor with jet engines carried by the blades, efficiency of jet engine operation requires a relatively high velocity of movement of the jet, yet it is advantageous to avoid excessively high rotor blade tip speed. A proposed arrangement satisfies both of these considerations by providing high velocity movement of the jet, while at the same time avoiding excessively high blade tip speed. This is accomplished by extending supports from the rotor blade tips and carrying the jet engines at the outer ends, thereby increasing speed of the jet relative to blade tip speed.

It is desirable to avoid excessively large blade swinging movements, either in the flapping sense or in the lag-lead sense, about the pivots used to mount sustaining rotor blades. It is also desirable to reduce such movements about the root end mounting pivots. The desired reductions in movement are accomplished by locating the jet at the outer ends of the extensions. The increased radius of rotation of the jet weight exercises a substantial influence tending to restrict the extent of blade swinging movements.

Various bending moments in the blades and extensions are relieved by a pivotal connection between the blade tips and the extensions. Although the extensions are of aeroform section, they are mounted so as to operate at substantially zero effective lift incidence, and the blades are set to operate at an appreciable positive effective lift incidence. It is contemplated that blade tip speed will be kept below the transonic range (from 600 to 750 fps), while the jets operate, under many conditions, at supersonic speeds.

Jet driven sustaining rotor (Patent No. 2,776,016). Harris S. Campbell, Bryn Athyn, Pa., assignor to Autogiro Co. of America.



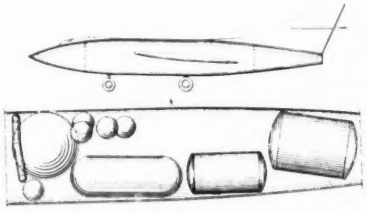
Plan view (top) of helicopter with jet engine mounted on rotor blade tip extension. Sectional views show how extension is hinged to blade tip.

Fuel Tank System Minimizes Shifts in Center of Gravity

In experimental research aircraft using liquid propellant rocket engines, the propellants present a hazard, since any leakage or malfunction of the transfer system can cause an explosion. Existing systems use arrangements in which the propellants are not completely isolated from one another, and it is therefore possible for one propellant to mingle with another. These propellants are ordinarily explosive when in contact with one another.

An example of such propellants is a dual system using a first propellant composed of an alcohol and water mixture, and a second propellant of liquid oxygen. Such systems have usually been employed in pilotless aircraft and the safety of the transfer system is not a critical factor, except for the high cost of losing the vehicle in an accident.

A recent invention for increasing safety in research aircraft is a liquid propellant transfer system for rocket engines, in which three different propellants are transferred from tanks to the engine through independent circuits. The system permits selective flow through the conduits in predetermined sequence under the pilot's control.



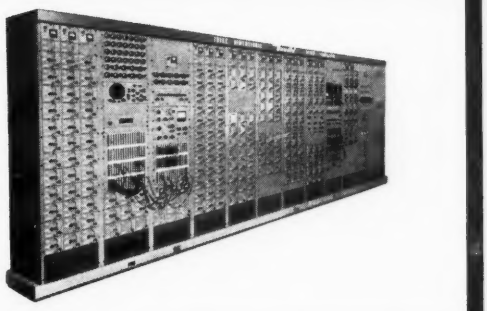
Side view of experimental aircraft (top), and an enlarged view illustrating diagrammatically the location of fuel tanks relative to the fuselage.

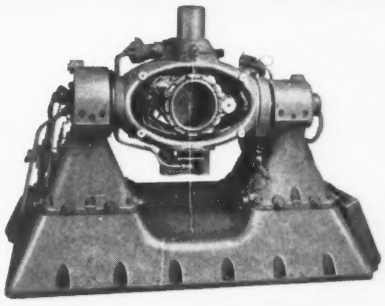
The proposed new system provides safe and reliable operation with minimum pilot effort and attention. The absence of interconnecting conduits prevents one propellant from coming into contact with another before entering the combustion chamber. Automatic vents in the tanks prevent build-up of dangerous gas pressures, and means are provided for jettisoning propellants before landing.

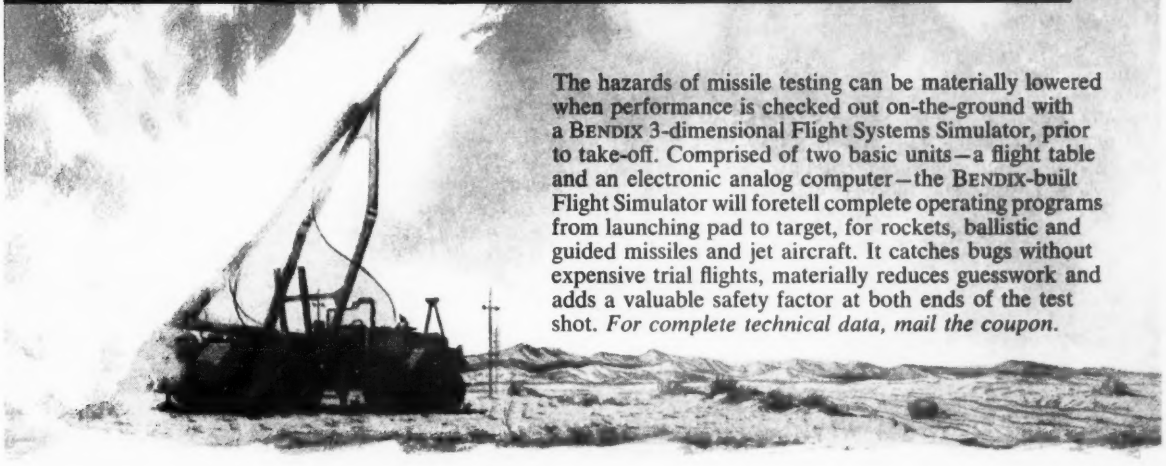
In high speed research aircraft the fuselage is heavily cross-braced, leaving no single large compartment for propellant tanks. Therefore, odd-shaped tanks are necessary, but this feature solves another problem. Rapid consumption of propellants shifts the center of gravity of the aircraft as propellants are consumed. In this system each propellant is contained in a pair of tanks, and fuel is fed from a lower tank of each pair of tanks to the engines. The upper tank of each pair feeds into the lower tank until the upper tank is empty. Lower tanks, which are last to empty, are close to the center of gravity, minimizing center-of-gravity shifts.

Liquid propellant transfer system (Patent No. 2,791,087). John A. Gorgenson and Milton U. Clauser, Palos Verdes Estates, Calif., assignors to the U. S. Navy.

Bendix flight simulators reduce the risks







The hazards of missile testing can be materially lowered when performance is checked out on-the-ground with a BENDIX 3-dimensional Flight Systems Simulator, prior to take-off. Comprised of two basic units—a flight table and an electronic analog computer—the BENDIX-built Flight Simulator will foretell complete operating programs from launching pad to target, for rockets, ballistic and guided missiles and jet aircraft. It catches bugs without expensive trial flights, materially reduces guesswork and adds a valuable safety factor at both ends of the test shot. *For complete technical data, mail the coupon.*

Bendix Computer

OFFICES IN WASHINGTON, D.C., DALLAS, LOS ANGELES AND CHICAGO

Export Representatives
Computing Devices of Canada, P. O. Box 508, Ottawa 4, Ontario
Bendix International Division, 205 E. 42nd Street, New York 17, N.Y.

BENDIX COMPUTER DIVISION—BENDIX AVIATION CORPORATION
5630 ARBOR VITAE STREET, LOS ANGELES 45, CALIFORNIA

☐ *Please mail me information on The Flight Systems Simulator.*

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

people in the news

Appointments

Theodore T. Magel has been named to the new post of assistant to the vice-president and technical director, Allegheny Ludlum Steel Corp., with responsibility for nuclear materials development. Magel was formerly vice-president in charge of development at Nuclear Metals, Inc.

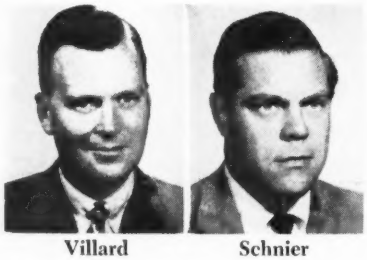
O. G. Villard Jr., Stanford University professor and senior member of the school's radio propagation laboratory, has been named to the board of Ling Electronics.

Gerald Rosenberg has been elected a vice-president of Consolidated Diesel Electric Corp.

Minneapolis-Honeywell Regulator Co. has given **Stephen F. Keating,** vice-president in charge of its Aeronautical Div., responsibility for all the company's activities in the military field.

W. M. Hylton has been named assistant to the vice-president and general manager of Rheem Aircraft Div. He was formerly with Ryan Aeronautical Co.

American Potash & Chemical Corp. has named **George W. Schnier** head of a newly formed chemical fuels section which will handle sales of products used in the manufacture of fuels for rockets, missiles and other applications.



Villard **Schnier**

Joseph A. Galambos, physicist, has joined the Guided Missile Research Div., Ramo-Wooldridge Corp.

Glenn C. Bach has been named chief production test pilot by Republic Aviation Corp.

Russell C. Galbraith has been named director of financial operations of Lockheed Aircraft Corp.'s California Div.

Defense Reserve Award to Aerojet

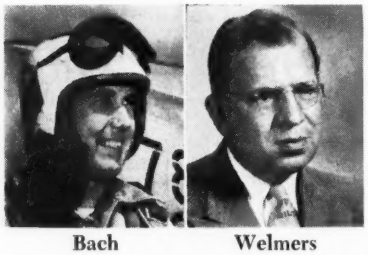
Dan Kimball (right), president of Aerojet-General Corp., accepts Defense Dept. Reserve Award from Rear Adm. C. C. Hartman, Commandant of the 11th Naval District. Company was honored for its support of Naval Reserve Research Co. 11-9, which has many Aerojet members.

Bell Aircraft Corp. has appointed **Everett T. Welmers** director of the Lawrence D. Bell Research Center, which will carry on research in aeronautics and allied fields.

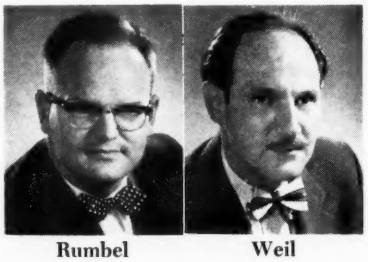
Englehardt A. Eckhardt, formerly vice-president in charge of research, Gulf Research & Development Co., has been named assistant director of the National Science Foundation for the division of mathematical, physical and engineering sciences.

Lester L. Weil and **Keith E. Rumbel** have been elected vice-presidents of Atlantic Research Corp. Both have been on the staff as divisional directors for some years.

Harry H. Greenwald has been elected vice-president, finance, for Pacific Airmotive Corp. He will continue to serve as treasurer and board member.



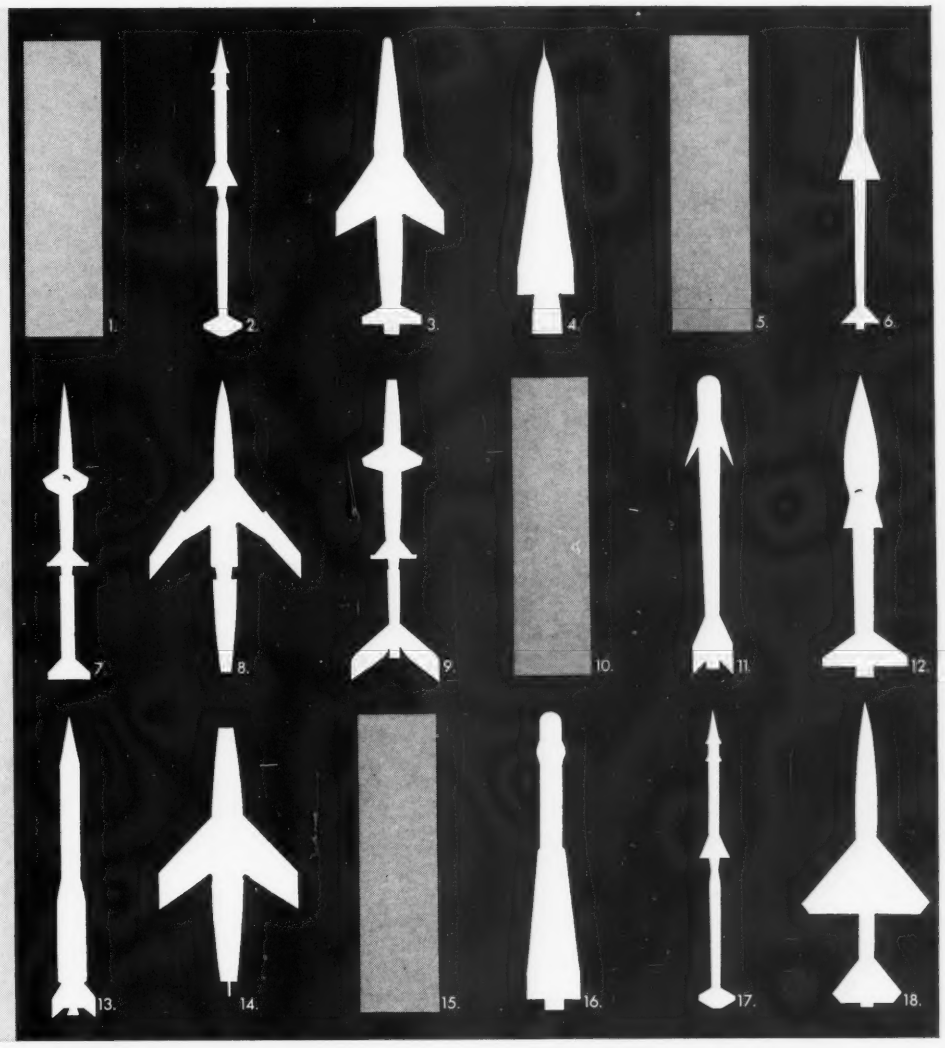
Bach **Welmers**



Rumbel **Weil**

A major reorganization of the engineering department at Hamilton Standard Div. of United Aircraft Corp. has resulted in the promotion of **Donald G. Richards** to the new post of chief of technical staff and **Walter C. Shaw** to chief of preliminary design.

James C. "Dick" Chapin, former test pilot for North American Aviation, has been named general sales manager and **Raymond J. Desbiens,** formerly with Garrett Corp., purchasing director at Darco Industries.



1. ATLAS
2. NIKE
3. LACROSSE
4. HAWK
5. THOR
6. SPARROW
7. TERRIER
8. SNARK
9. TALOS
10. TARTAR
11. SIDEWINDER
12. LITTLE JOHN
13. TITAN
14. REGULUS
15. GOOSE
16. FALCON
17. NIKE B
18. BOMARC

Pick a program . . . you'll find

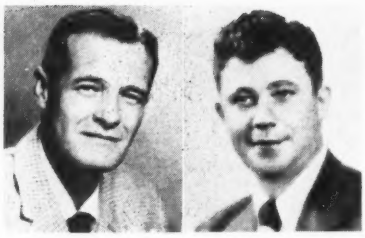
AMF has missile experience you can use

In program after program, including each of those above, AMF has played or is playing an important role. A component supplier in some, a system developer in others, AMF knows the missile business first-hand. • AMF contributions to the nation's missile programs include test and check-out systems, handling and launching equipment, on-site missile storage facilities, accessory power supplies. • See for yourself why AMF's widely diversified background plus its up-to-the-minute missile activities add up to "experience you can use".

Research, Development, Production in these fields:
- *Armament*
- *Ballistics*
- *Radar Antennae*
- *Guided Missile Support Equipment*
- *Auxiliary Power Supplies*
- *Control Systems*

Another AMF Product
DEFENSE PRODUCTS

Defense Products Group
AMERICAN MACHINE & FOUNDRY COMPANY
1101 North Royal Street, Alexandria, Va.

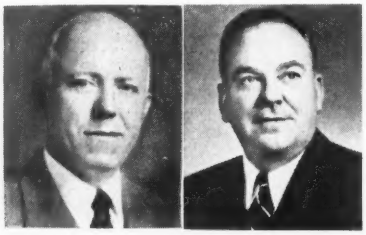


Moore Shriver

Max Moore has been named chief engineer for the Precision Potentiometer Div., General Controls Co.

Edward N. Cooley has been appointed vice-president in charge of ALCO Products' Thermal Products and Petroleum Industry Equipment Divs.

Robertshaw-Fulton Controls Co. has elected **Thomas T. Arden** president and **John A. Robertshaw,** former president, board chairman. Arden and Robertshaw will be members of a three-man executive committee headed by **Richard S. Reynolds Jr.,** former board chairman.



Arden Robertshaw

Millard D. Shriver has been appointed to the new post of vice-president and assistant to the president, Panellit, Inc.

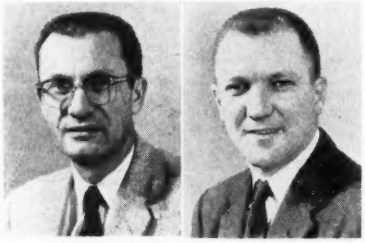
Three new staff positions have been announced by the Eclipse Machine Div. of Bendix Aviation. **Nelson H. Mageoch** has been named assistant general manager, and **Joseph W. Poliseo** and **Robert W. Sutton** have been appointed chief engineer and assistant chief engineer, respectively, of a new electronics engineering department.

John Roback has been promoted to engineering manager and **C. R. Lambert,** formerly with Daystrom, Inc., has been named operations manager of the Data Reduction and Automation Div., Fischer & Porter Co. **Louis Aricson,** F & P administrative vice-president, is now responsible for general management of the division.

Robert M. Briney has been appointed president of Haynes Stellite Co., Div. of Union Carbide Corp. Briney has been with the corporation since 1924.

Leland W. Brown has been appointed field engineering training manager for the ElectroData Div. of Burroughs Corp.

American Electronics, Inc., has announced the appointment of **Ed Kinney** as chief engineer, **Robert Webb** as chief application engineer and **Richard C. Brubaker** as controller of its Audio and Recordata Divs.



Kinney Webb

Morton G. Scheraga has been named instrument product manager of Allen B. Du Mont Laboratories, Inc.

Frank W. Clark and **Milton D. Blauner** have been named to the board of Universal Transistor Products Corp.

International Resistance Co. has named **F. P. Rice** president of its subsidiary, Circuit Instruments, Inc. Rice was formerly with Allen B. Du Mont Laboratories.

Antonides Hatcher

Joseph W. Antonides has been appointed vice-president for solid propellant operations at Reaction Motors, Inc., responsible for coordinating research, development and production programs. He was formerly executive assistant to the president and will continue in that capacity in addition to his new duties.

R. Adm. R. S. Hatcher (USN Ret.), former assistant chief of research and development of the Navy's Bureau of Aeronautics, has joined Aerojet-General Corp. to work in the field of advanced planning.

Kenneth Stiles has been named to the new post of vice-president, plans and programs, General Dynamics Corp. A former Deputy Assistant Secretary of the Army, Stiles has been assistant to the executive vice-president of the company since 1953.

Lear, Inc., has named **Edward F. Conklin** general manager of its Lear-Cal Div.

Arthur W. Byxbee has been appointed general manager of the new Pacific Coast Div. of Raybestos-Manhattan, Inc. The new division was established following purchase by the company of Graef Engineering Co. in Paramount, Calif.

Robert J. Browne has been named chief engineer and general manager of the new Philadelphia Pump Div. of American Meter Co.

Consolidated Electrodynamics Corp. has made **P. H. Girouard** director of its newly formed DataTape Div. He was formerly assistant director of engineering.

Lt. Gen. Thomas S. Power has been named Commander of the Strategic Air Command, succeeding Gen. Curtis E. LeMay, who has been assigned as AF Vice-Chief of Staff.

Honors

Rear Adm. Delmar S. Fahrney (USN Ret.) has received a second Legion of Merit for his work in developing a successful assault drone in

Delmar S. Fahrney

World War II. Adm. Fahrney is now completing a book on the history of guided missiles under a Bureau of Aeronautics contract.

Lt. Col. Frank K. Everest Jr., Air Force rocket plane test pilot, has received the Institute of Aeronautical Sciences 1957 Octave Chanute award "for his outstanding contributions to the development of rocket-powered flight test techniques."

The Royal Aeronautical Society in London has elected **Edward H. Heinemann,** chief engineer of the Segundo Div., Douglas Aircraft Co., a Fellow Member.

Mark of a New and Deadly Guided Missile

"Sidewinder" is the Navy's newest air-to-air guided missile. Flight tests have proved the missile to be as vicious as the desert rattlesnake for which it was named.

In brilliant performances against airborne targets at China Lake, "Sidewinder", Navy's new air-to-air guided missile, has captured the attention of the entire missile industry.

Simple in operation, small and light enough to be carried in quantity by single-seat Interceptors, "Sidewinder" can be fired singly or in salvos. It requires no complex launching system or special pilot training, and it maneuvers deftly at supersonic speeds. The missile displays extremely high single-shot accuracy —and even more important, *it can be launched well beyond reach of the target aircraft's defense.*

"Sidewinder" was developed by the Naval Ordnance Test Station of the Navy Bureau of Ordnance at China Lake, California. Philco assisted NOTS in the research and development program, and performed the subsequent engineering required for manufacture of the missile. "Sidewinder" is *now in full production at the Philco Government and Industrial Division.*

Philco is proud to have made this important contribution to the development of more effective electronic systems for our national defense.

PHILCO®

GOVERNMENT AND INDUSTRIAL DIVISION
PHILADELPHIA 44, PENNSYLVANIA

Deaths

Harold M. Hipsh, head of the aeronautical engineering department of Pennsylvania State University and organizer of the University Park Section of the ARS, died recently at the age of 34. A top missile design and

Harold M. Hipsh

research engineer, Dr. Hipsh had served in a consultant capacity on missile work for several government agencies and in 1950–1951 was senior design engineer on Air Force nuclear propulsion project.

Prior to coming to Penn State in November 1954, as professor of aeronautical engineering, Dr. Hipsh had been with Convair, Hughes and Bendix. A graduate of the California Institute of Technology, he began his career as an aerodynamicist and flight test engineer with General Motors.

Harold S. Rogers

Harold S. Rogers, president of the Polytechnic Institute of Brooklyn, died suddenly on June 6 at the age of 66. Dr. Rogers had been president of Polytechnic since 1933, following a term as dean of engineering at Oregon State College. During his 24 years as president, enrollment at the school grew from less than 2000 students to a point where Polytechnic is now the second largest school of science and engineering in the country.

Alvin E. Hewitt and **Addison B. Conroy,** president and vice-president, respectively, of Aeroduct, Inc., were killed in a recent plane crash.

Atlas ICBM Takes to Air—Briefly

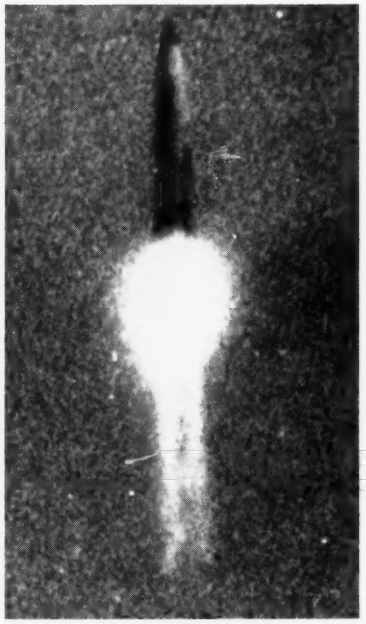
Convair's Atlas ICBM aborted after less than a minute of flight following a beautiful take-off at Cape Canaveral, Fla., June 11. Though supposedly super secret, its debut was watched by hundreds of civilians from beaches three miles from the base. Photographers and reporters were also legion.

Air Force officers in Washington seemed to have little quarrel with some of the details printed about the big "bird" in the flurry of press reports. They took issue only when the test was termed unsuccessful.

The consensus was that the Atlas, with twin streams of flame burning cleanly, rose to about 8000 ft before one of the first-stage engines developed trouble. Dense black smoke, apparently due to incomplete combustion of fuel, began spewing from the silver missile, sending it into a dive.

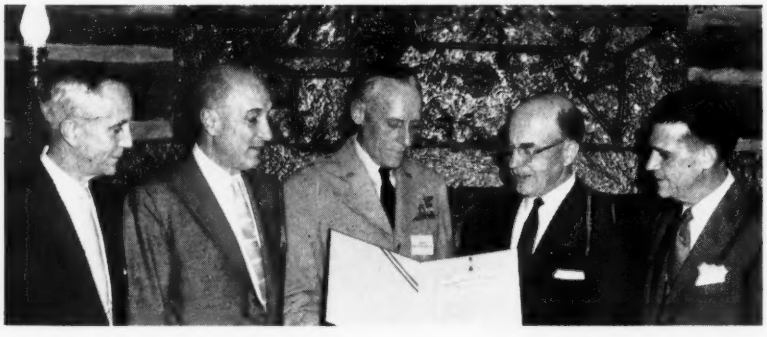
The bird righted itself, presumably by means of a gimballed motor mechanism, only to waver once again. Safety officers at the range then broke the cigar-shaped missile in two, the pieces spiralling into the sea.

At least two reports "revealed" that the first stage consisted of two engines which, with a skirt, were scheduled to drop away. A third centered engine provided second-stage thrust. The third stage consisted of the nose section which pursues a ballistic, unpowered trajectory to target.



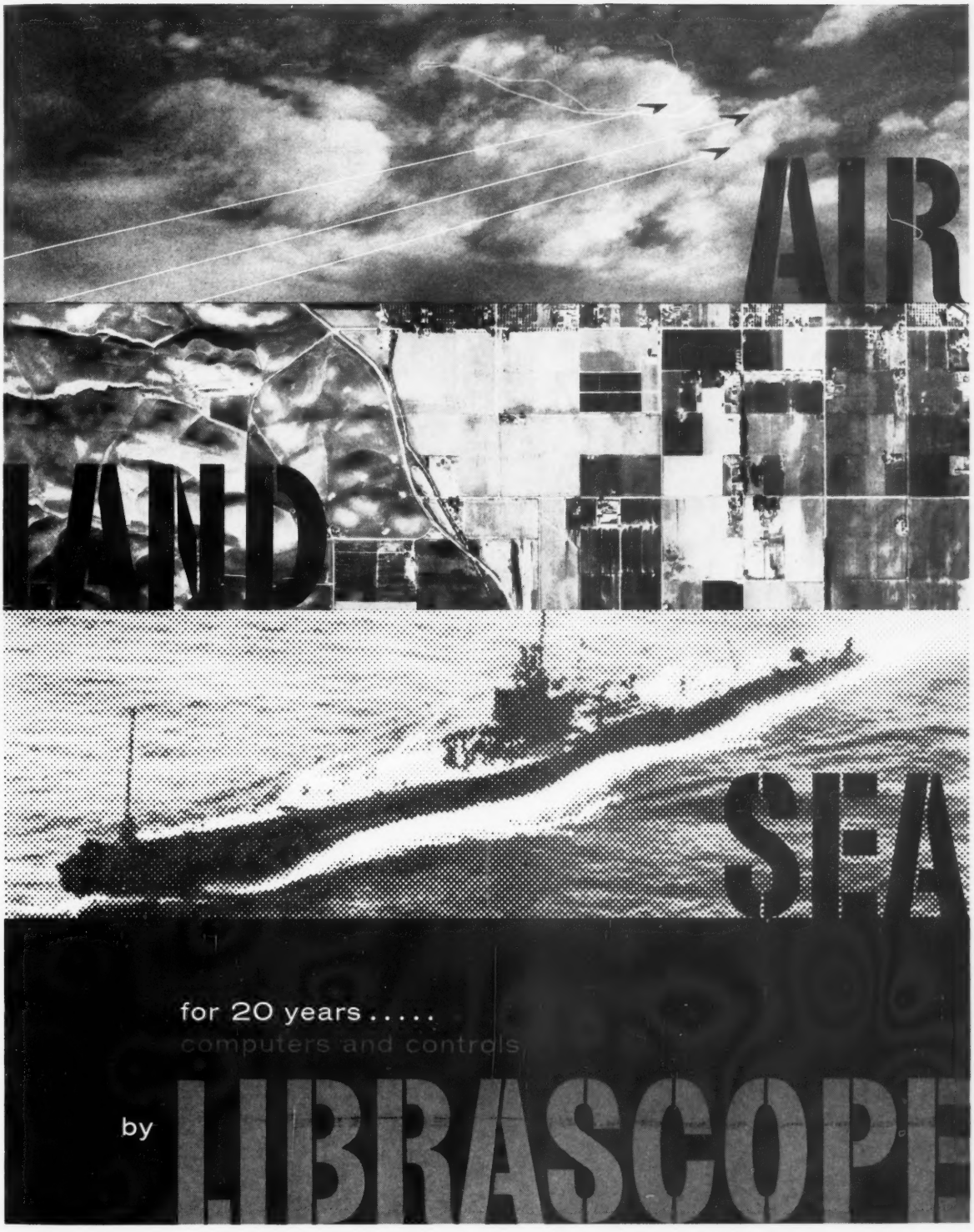
Atlas at about 4000 ft above Cape Canaveral in June 11 test firing. What looks like pointed nose cone may be result of film graininess.

Reported height of the Atlas ranged between 70 and 100 ft. One newspaper estimated its diameter as 11 ft. Pumping difficulties or uncontrollable vibrations were alternately blamed for the misfire.



Phillips Honored for Work on Propellants

Maj. Gen. John W. Sessums Jr. (center), vice-commander, ARDC, presents the Air Force Scroll of Appreciation to Phillips Petroleum Co. officials. The scroll, highest AF award to industry, was presented for the company's outstanding service in the field of solid propellant rocketry.

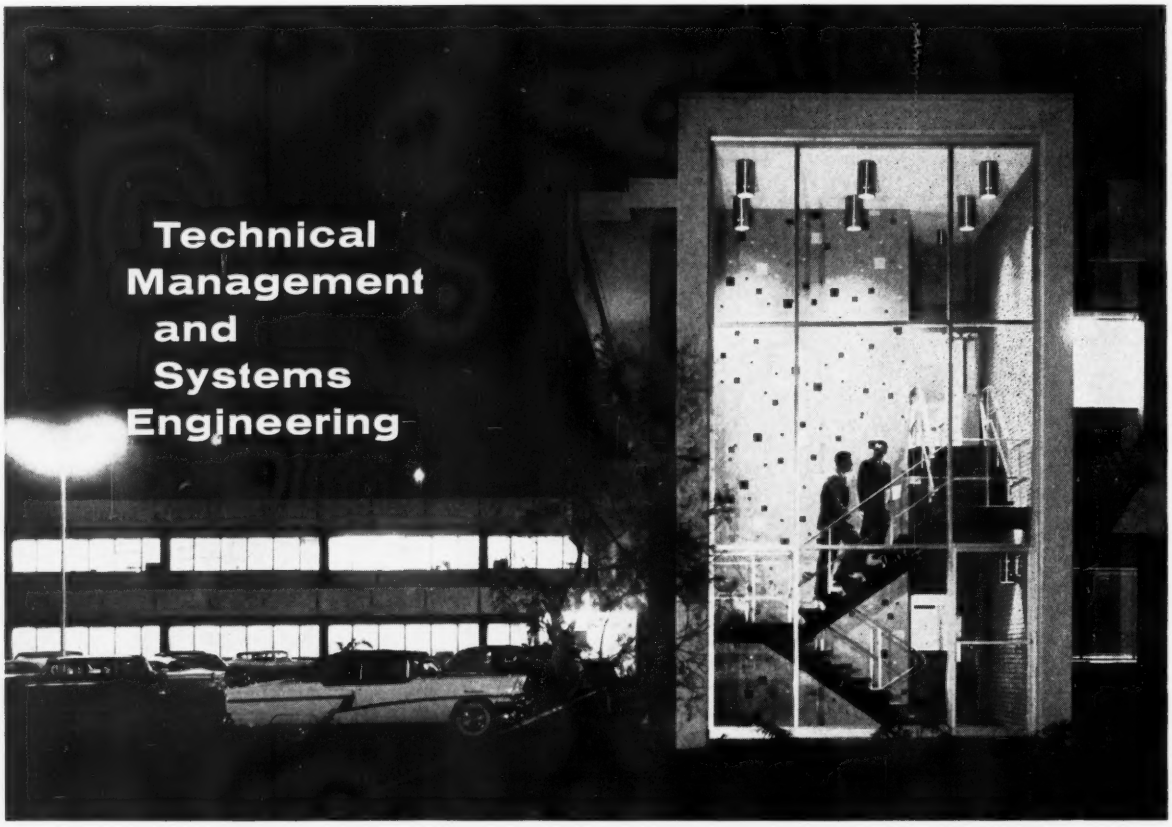


EXPERIENCE AND VERSATILITY have earned for Librascope a position of leadership in the design, development and manufacture of computers and controls for military and industrial applications. Through extensive experience in the combination of electronic, magnetic, mechanical and optical design concepts, Librascope can offer an impressive capacity for achievement in the development of precision instrumentation. This knowledge, gained over a twenty year period, can be focused on *your* computer-control problem... with marked success! Your inquiry is invited.

Engineers capable of significant contributions are invited to write Glen Seltzer, Employment Manager

A SUBSIDIARY OF GPE LIBRASCOPE

LIBRASCOPE, INCORPORATED • 808 WESTERN AVENUE • GLENDALE, CALIFORNIA



In systems engineering work, it is necessary to bring together a team that includes scientists and engineers of a wide range of technical specialties. In major weapons-systems projects, such teams will include hundreds of scientists and engineers.

But the assembly of a large group of scientists and engineers, no matter how capable they may be individually, does not of itself ensure good systems-engineering performance. The caliber of the project management has a major effect upon its technical accomplishment. It is not easy to coordinate the activities of large numbers of scientists and engineers so as not to stifle their creativeness on the one hand, nor to permit the various development sub-efforts to head toward mutually incompatible objectives on the other.

Of primary importance for good systems management is the philosophy underlying the selection of the supervisory personnel. The head of a technical activity should, first of all, be a competent scientist or engineer. A common mistake – nearly always fatal in systems work – is to fill such positions by non-technical men who have been trained only in management techniques. In the highly complex activities of major systems work, what is required is *technical management*, and of the two words, the word *technical* must never be overlooked.

In the selection of scientists and engineers for technical management, it is essential that the men chosen be broad in their training and approach. Each principal department head, for example, must have a good basic understanding of the technical facts of life of the other departments. When these people get together they need to speak a common language and understand each other's fields, so that proper decisions can be made on the many interrelated problems that come up. The higher the organizational responsibility of a technical manager, the more important this factor becomes.

The Ramo-Wooldridge Corporation is engaged almost entirely in systems work. Because of this, the company has assigned to scientists and engineers more dominant roles in the management and control of the business than is customary or necessary in most industrial organizations.

Scientists and engineers who are experienced in systems engineering work, or who have specialized in certain technical fields but have a broad interest in the interactions between their own specialties and other fields, are invited to explore openings at The Ramo-Wooldridge Corporation in:

Guided Missile Research and Development
Aerodynamics and Propulsion Systems
Communications Systems
Automation and Data Processing
Digital Computers and Control Systems
Airborne Electronic and Control Systems
Basic Electronic and Aeronautical Research

The Ramo-Wooldridge Corporation

5730 ARBOR VITAE ST. • LOS ANGELES 45, CALIF.

FACTS

about

NEW DEPARTURE BALL BEARINGS

WITH 50 YEARS
BALL BEARING EXPERIENCE
AND THE MOST ADVANCED
METHODS IN THE INDUSTRY TODAY

NEW DEPARTURE

PRODUCES A COMPLETE LINE OF
ULTRA-FINE SMALL BEARINGS FOR
YOUR PRECISION INSTRUMENT
REQUIREMENTS

Catalog on Request

NEW DEPARTURE—World's Foremost Producer of Fine Ball Bearings

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

SIXTY SECONDS TO CATCH A SUNFLARE

IGY leads off with an assist from CDC

Sunflares leap into space at velocities which stagger the imagination. They occur without warning and last but a few minutes. To get vital sunflare information when it's available CDC rocket crews get the two-stage research rocket off in sixty seconds! Then, from an 80 to 150-mile-high vantage point, instruments in the NIKE-DEACON or NIKE-ASP combination detect and telemeter data on the sun's radiation—important new information to expand our knowledge of radio propagation.

CDC was awarded the IGY Sunflare contract by the Naval Research Laboratory, and was responsible for modifying and assembling the two-stage rocket vehicle, and building the instrumentation-telemetering head. Here is another important activity where CDC skills are helping speed the answers to questions in high-altitude research.

COOPER DEVELOPMENT CORP.

2626 S. Peck Road, Monrovia, California

Designers and builders of the ASP—the world's fastest single-stage solid propellant rocket.

Scientists and creative engineers . . . investigate this field with a future. Challenging working environment in Southern California.

Launched toward the Future in WEAPON SYSTEMS MANAGEMENT

Rascal—GAM-63 air-to-surface missile of the USAF—is an operational example of complete weapon systems management by Bell Aircraft. As prime contractor, Bell's responsibilities embraced the design, development, and production of the entire system including airframe, guidance, rocket engine, servo-mechanical devices, launching and ground support equipment as well as flight testing and training.

The personnel responsible for this successful program has recently been regrouped to form a new, autonamous ***Guided Missiles Division.*** Its sole function is to provide complete and coordinated management and production for any weapon systems program.

The men who make up this division are a skilled and diversified team of specialists with a total of some 100,000 man-years of experience in guided missiles. Prior to "Rascal", they were responsible for Tarzon, Shrike and Meteor. Current responsibilities also include important components for the Nike, Regulus, Navaho and various I. C. B. M. and I. R. B. M. programs.

These men have past success to attest to their capabilities and foretell future accomplishments. They will be heard from again and again for important achievements in the years ahead.

BELL Aircraft CORP.

Guided Missiles Div.
BUFFALO, N. Y.

government contract awards

GE Gets $158 Million AF Nose Cone Contract

The Air Force has awarded the General Electric Co. a $158 million contract for development work on nose cones for its ICBM Atlas and IRBM Thor missiles. The work will be carried on exclusively at GE's Missile and Ordnance Systems Dept. in Philadelphia.

The company already has received authority to commence development work on nose cones under a previously issued letter contract.

Westinghouse Gets Contract For Polaris Launching System

Westinghouse Electric Corp. has been awarded a $10 million Navy contract for the design and manufacture of an experimental handling and launching system for the Polaris missile, now under development. The contract calls for design of a series of test systems leading to launching of the missile from surface ships and submarines, and includes both electrical and mechanical launching devices.

Work carried out under the program will be centered at the company's Sunnyvale, Calif., plant.

Following is a synopsis of government contracts for each Air Force, Army and Navy contracting office of advertised and negotiated unclassified contracts in excess of $25,000 in the rocket, missile and jet propulsion fields:

Air Force

AF Cambridge Research Center, ARDC, Hanscom Field, Bedford, Mass.

Research directed toward the study of solar-terrestrial relationships, $70,000, **Geo-Science, Inc.**, South Rd., Alamogordo, N. Mex.

Design and construction of swept-frequency interferometer type radio receiver, $36,295, **Airborne Instruments, Inc.**, 160 Old Country Rd., Mineola, N. Y.

Research directed toward the spectral emissivity of certain high temperature materials, $30,515, **Arthur D. Little, Inc.**, 30 Memorial Dr., Cambridge, Mass.

Development of special purpose analog tracking equipment, $51,324, **AVCO Mfg. Corp., Crosley Div.**, 1329 Arlington St., Cincinnati, Ohio.

AF Flight Test Center, ARDC, Edwards AFB, Calif.

Design and modify propellant distribution system on test stands 1-3, 1-4 and 1-5, $33,822, **Petersen Construction Co.**, 431 W. Chestnut Ave., Monrovia, Calif.

Gaseous helium semitrailers, $134,844, **Nichols Engineering Co. & Assoc.**, 8964 Huntington Dr., San Gabriel, Calif.

Modification kit for helium pump, $26,975, **Haskel Engineering & Supply Co.**, 1236 S. Central Ave., Glendale 4, Calif.

Helium gas purification system and filters, $121,161, **Precision Equipment Co., Inc.**, 1641 Border Ave., Torrance, Calif.

Multiple playback unit, $55,300, **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif.

High pressure helium booster system, $45,610, **Haskel Engineering & Supply Co.**, 1236 S. Central Ave., Glendale 4, Calif.

AF Missile Test Center, ARDC, Patrick AFB, Fla.

Three airborne telemetry antennas, $31,689, **Dynatronics, Inc.**, 717 W. Amelia Ave., Orlando, Fla.

Two high speed output buffer systems, $106,844, **Telemeter Magnetics, Inc.**, 2245 Pontius Ave., Los Angeles, Calif.

Clarification of specifications, extension of delivery date and allotment of additional cost overrun funds, $222,275, **Cubic Corp.**, 5575 Kearney Villa Rd., San Diego, Calif.

Increase in funds allotted, $35,438, **Electronic Engineering Co. of Calif.**, 180 S. Alvarado St., Los Angeles, Calif.

Aviation Supply Office, 700 Robbins Ave., Philadelphia 11, Pa.

Various spare parts for liquid oxygen trailer, Prenll-4234/57, $48,423, **Ronan & Kunzl, Inc.**, 502 S. Kalamazoo Ave., Marshall, Mich.

Base Procurement Office, Eglin AFB, Fla.

Digital data system, $34,200, **Vitro Lab., Inc., of America**, 200 Pleasant Valley Way, W. Orange, N. J.

Commander, HQ AMC, Wright-Patterson AFB, Ohio.

J71-A-2 turbojet engines for F3H aircraft, $12,337,920, **Allison Div., General Motors Corp.**, PO Box 894, Indianapolis 6, Ind.

Gas turbine generator sets, Type MA-1, and burner assembly for KC-97 aircraft, $1,384,202, **Solar Aircraft Co.**, 2200 Pacific Highway, San Diego 12, Calif.

Liquid Oxygen

is handled safely and economically when vacuum insulated liquid oxygen Cryotainers* are used.

RONAN & KUNZL, INC. has been producing high vacuum, low loss, simple to operate containers for liquid oxygen for six years. A prime producer for the Air Force and Navy, air frame manufacturers, laboratories and gas distributors use them. Why don't you?

For information, call, wire or write:

CRYOGENIC DIVISION
RONAN & KUNZL, INC.
MARSHALL MICHIGAN
Phone: STORY 1-2861

OR

6214 WEST MANCHESTER AVE.
LOS ANGELES 45, CALIFORNIA
Phone: ORCHARD 4-7240

* REG. TRADE MARK

San Antonio R&D Procurement Office, ARDC, PO Box 63, San Antonio, Tex.

Research and reports on effects of ionizing radiation on physiological and psychological functions of various species, AF Contract 41(657)-149, $255,928, **University of Texas,** Austin, Tex.

Research and reports on design, establishment and maintenance of a comparative environmental physiology laboratory, $34,500, **University of Alaska,** College, Alaska.

Army

Boston Ordnance District, Army Base, Boston 10, Mass.

Manufacture of heads, rocket, HE, 762 mm, T2021, MPTS, $38,935, **Hicks Corp.,** 1671 Hyde Pk. Ave., Boston, Mass.

Chicago Engineer District, 475 Merchandise Mart, Chicago 54, Ill.

Construction of jet engine test cell at Truax Field, Madison, Wis., $225,916, **Shaw & Estes,** 1407 S. Akard St., Dallas, Tex.

Los Angeles Engineer District, 751 S. Figueroa St., Los Angeles 17, Calif.

Wind tunnel engineering building at Jet Propulsion Laboratory, Pasadena, Calif., $96,889. **Jack Polstein,** 10138¼ E. Rust St., El Monte, Calif.

Los Angeles Ordnance District, 55 S. Grand Ave., Pasadena, Calif.

Combustion pressure control systems, $28,766, **Servomechanisms, Inc.,** 12500 Aviation Blvd., Hawthorne, Calif.

Corporal ground guidance control equipment, amplifier electronic control, AM-1072/DJW1, $262,400, **Gilfillan Bros., Inc.,** 1815 Venice Blvd., Los Angeles, Calif.

Replenishment repair parts for guided missile artillery M2 and related ground handling equipment, $29,234 and $55,140, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Corporal ground guidance equipment, $600,000, and engineering services related to the Corporal missile system, $1,056,345, **Gilfillan Bros.,** 1815 Venice Blvd., Los Angeles 6, Calif.

Spare parts for Nike system, $28,369, **Douglas Aircraft Co., Inc.,** 3000 Ocean Pk. Blvd., Santa Monica, Calif.

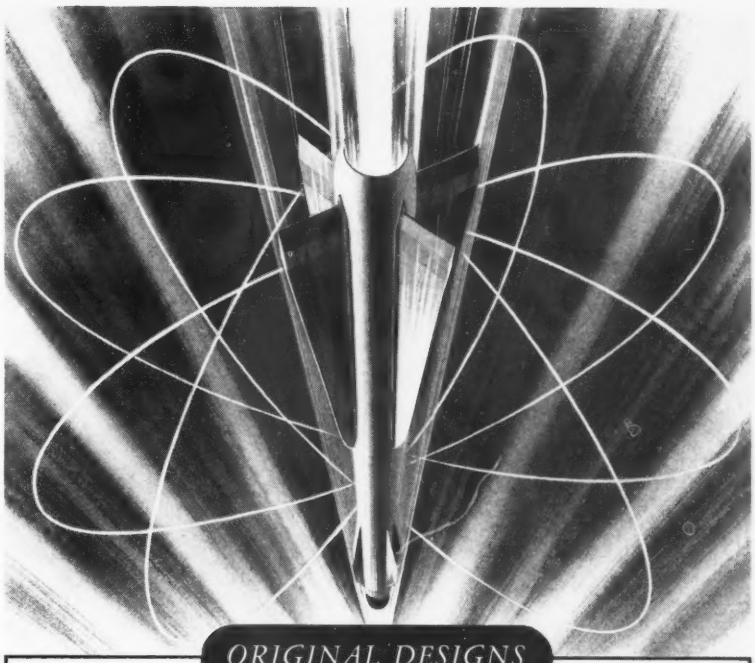
Replenishment repair parts for guided missile artillery M2 and related ground handling equipment, $49,815 and $47,333, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Engineering, investigation and development, $291,000 and $50,000, **North American Aviation,** 6633 Canoga Park, Calif.

Furnishing and delivery of repair parts, documentation and training equipment related to Corporal missile system, $503,825, **Gilfillan Bros.,** 1815 Venice Blvd., Los Angeles 6, Calif.

Mobile Engineer District, 2301 Grant St., Mobile, Ala.

Construction of BOMARC-OST facilities at Eglin AFB, Fla., $651,847, **Greenhut Construction Co.,** Pensacola, Fla.

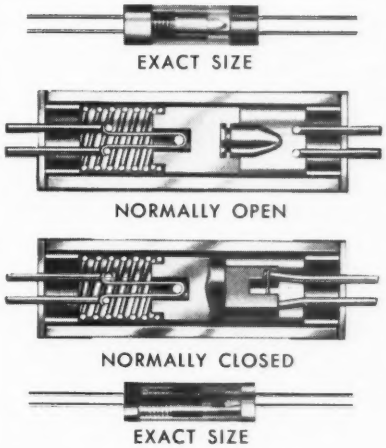


ORIGINAL DESIGNS

MINIATURE THERMAL RELAYS

with

99.99% PLUS RELIABILITY



Our complete environmental testing laboratory samples and certifies daily production.

New NORMALLY CLOSED RELAYS NOW AVAILABLE. Hermetically sealed by an exclusive process of bonding metal headers to high thermal, shock resistant glass housings. Designs are based on the "fuse burnout" principle and will open or close a circuit *positively* in 0.1 second or other delay times. They can also be safely used as a "squib" or timing mechanism.

Relays have been qualification tested for high performance and are being used extensively on current production missiles and complex electronic equipment.

Withstand extreme conditions of temperature (−100°F to +450°F), shock (250 G's), vibration (20-3000 cps at 40 G's), and precise electrical characteristics with the added feature of visibility.

WHAT ARE YOUR REQUIREMENTS?

Write TODAY for new Brochure containing detailed characteristics and specifications.

NETWORKS ELECTRONIC CORPORATION

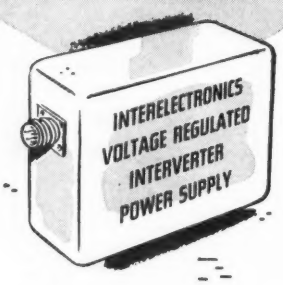
14806 OXNARD STREET, VAN NUYS, CALIFORNIA

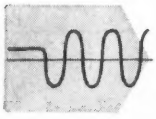
Original designs for highest reliability in glass housed miniature Relays and Resistors for all purposes.

SEE US AT WESCON BOOTH 1214

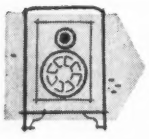
NEW!

DC to DC and DC to AC solid-state power converters voltage regulated, frequency controlled, for missiles, telemetering, gyros, servos

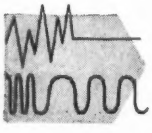




Interelectronics Interverter solid-state thyratron-like elements and magnetic components convert DC to any number of voltage regulated or controlled frequency AC or filtered DC outputs from 1 to 1800 watts. Light weight, compact, 90% or better conversion efficiency.

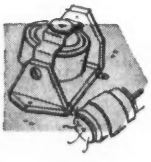


Ultra-reliable in operation, no moving parts, unharmed by shorting output or reversing input polarity. Complies with MIL specs for shock, acceleration, vibration, temperature, RF noise.



Now in use in major missiles, powering telemetering transmitters, radar beacons, electronic equipment. Single and polyphase AC output units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics — first and most experienced in the DC input solid-state power supply field, produces its own solid-state gating elements, all magnetic components, has the most complete facilities and know-how—has designed and delivered more working KVA than any other firm!



For complete engineering data write Interelectronics today, or call LUdlow 4-6200 in N. Y.

INTERELECTRONICS CORPORATION

2432 GR. CONCOURSE, N. Y. 58, N. Y.

Nashville Engineer District, 306 Federal Office Bldg., Nashville, Tenn.

Construction of jet engine test cell facility at McGhee-Tyson AFB, Knoxville, Tenn., $191,015, **Shaw & Estes,** 1407 S. Akard St., Dallas, Tex.

New York Ordnance District, 180 Varick St., New York 14, N. Y.

Development and construction of a rocket engine type combustion system, $585,200, **Reaction Motors, Inc.,** Denville, N. J.

Research and development of the Nike-Zeus (Nike II) guided missile system, $1,886,740, **Western Electric Co.,** 120 Broadway, New York 5, N. Y.

Philadelphia Ordnance District, 128 N. Broad St., Philadelphia, Pa.

Nike spare parts and components, $39,168, $35,403 and $41,600, **Western Electric Co.,** Burlington, N. C.

Recondition KTH-41 cinetheodolites to KTH-53's, coded circles for KTH-53's, aided tracking systems, mechanical components for digital computers, $150,524, **Askania-Werke-A.G.,** Bethesda, Md.

Design, development and fabrication of rocket motors for rocket assist catapult, $54,460, **Atlantic Research Corp.,** Alexandria, Va.

Nike spare parts and components, $27,739 and $44,352, **Western Electric Co.,** Burlington, N. C.

350,000 lb propellant powder (du Pont IMR-7013), $332,500, **E. I. du Pont de Nemours & Co.,** Wilmington, Del.

Purchasing & Contracting Div., White Sands Proving Ground, N. Mex.

Telescope astradomes, $39,000, **Alfred Hoffman & Co.,** 629–635 59 St., West New York, N. J.

Redstone Arsenal, Huntsville, Ala.

Hydrogen peroxide, 90% c.p. grade, $49,290, **E. I. du Pont de Nemours & Co.,** Wilmington, Del.

Continued development of XM16X1 rocket engine, $97,335, **Thiokol Chemical Corp.,** Trenton, N. J.

Continued development of XM16X1 JATO, $333,287, **Thiokol Chemical Corp.,** Trenton, N. J.

Liquid oxygen in tank cars, $49,500, **Linde Air Products,** 2900 Cahaba Rd., Birmingham, Ala.

Hydrogen peroxide, 76% c.p. grade, $27,427, **E. I. du Pont de Nemours & Co.,** Peroxygen Products Div., Electrochemical Dept., Wilmington 98, Del.

Continuation of R&D program on large solid propellant type engine, $787,000, **Thiokol Chemical Corp.,** Trenton, N. J.

Continuation of R&D program on propulsion unit for Hawk (XM-3) guided missile, $392,925, **Thiokol Chemical Corp.,** Trenton, N. J.

San Francisco Ordnance District, 1515 Clay St., PO Box 1829, Oakland 12, Calif.

Provide standard analytic methods for cost, schedule budget control over missile systems programs (end use: guided missiles), $97,730, **Stanford Research Institute,** Menlo Park, Calif.

Design, develop and fabricate two vehicle chassis of the T113 vehicle modified for the Little John missile system, $412,627, **Food Machinery & Chemical Corp.,** San Jose, Calif.

Signal Supply Agency, 225 S. 18th St., Philadelphia 3, Pa.

Nike-Cajun instrumentation units and grenade sections, $46,356, **Atlantic Research Corp.,** Alexandria, Va.

Inertial navigator installed and maintained for one year, $214,902, **Litton Industries,** Beverly Hills, Calif.

Springfield Ordnance District, Springfield 1, Mass.

16-channel telemetry discriminator system, $82,400, **Electro-Mechanical Research, Inc.,** Ridgefield, Conn.

Tullahoma Engineer District, Tullahoma, Tenn.

Construction of controls and instrumentation, Phase 1, supersonic circuit of the propulsion wind tunnel, Arnold Engineering Development Center, Tullahoma, Tenn., $1,041,440, **Wilson Electric Co.,** 1113 8th Ave., S., Nashville, Tenn.

Navy

Naval Avionics Facility, Indianapolis 18, Ind.

Electromagnetic type vibration test equipment, $91,355, **M. B. Mfg. Co. Div. of Textron, Inc.,** 1060 State St., New Haven 11, Conn.

Navy Dept. Bureau of Aeronautics, Washington 25, D. C.

Hydrogen peroxide services vehicle, $64,465, **Food Machinery & Chemical Corp. (Fla. Div.),** PO Box 1718, Lakeland, Fla.

Navy Dept. Bureau of Ordnance, Washington, D. C.

5 KS 4500 Mk 7 Mod 1 JATO's and igniters Mk 166 Mod 0(120), $723,232, and 1.8 KS-7800 rocket engine, $1,948,924, **Aerojet-General Corp.,** Sacramento, Calif.

Navy Purchasing Office, 1206 S. Santee St., Los Angeles 15, Calif.

Services and material to conduct a feasibility study, fabricate and install a self-calibrating guidance motor to monitor the guidance parameters of the AN/SPQ-5 Terrier guidance radar, $38,665, **Convair Div. of General Dynamics Corp.,** Pomona, Calif.

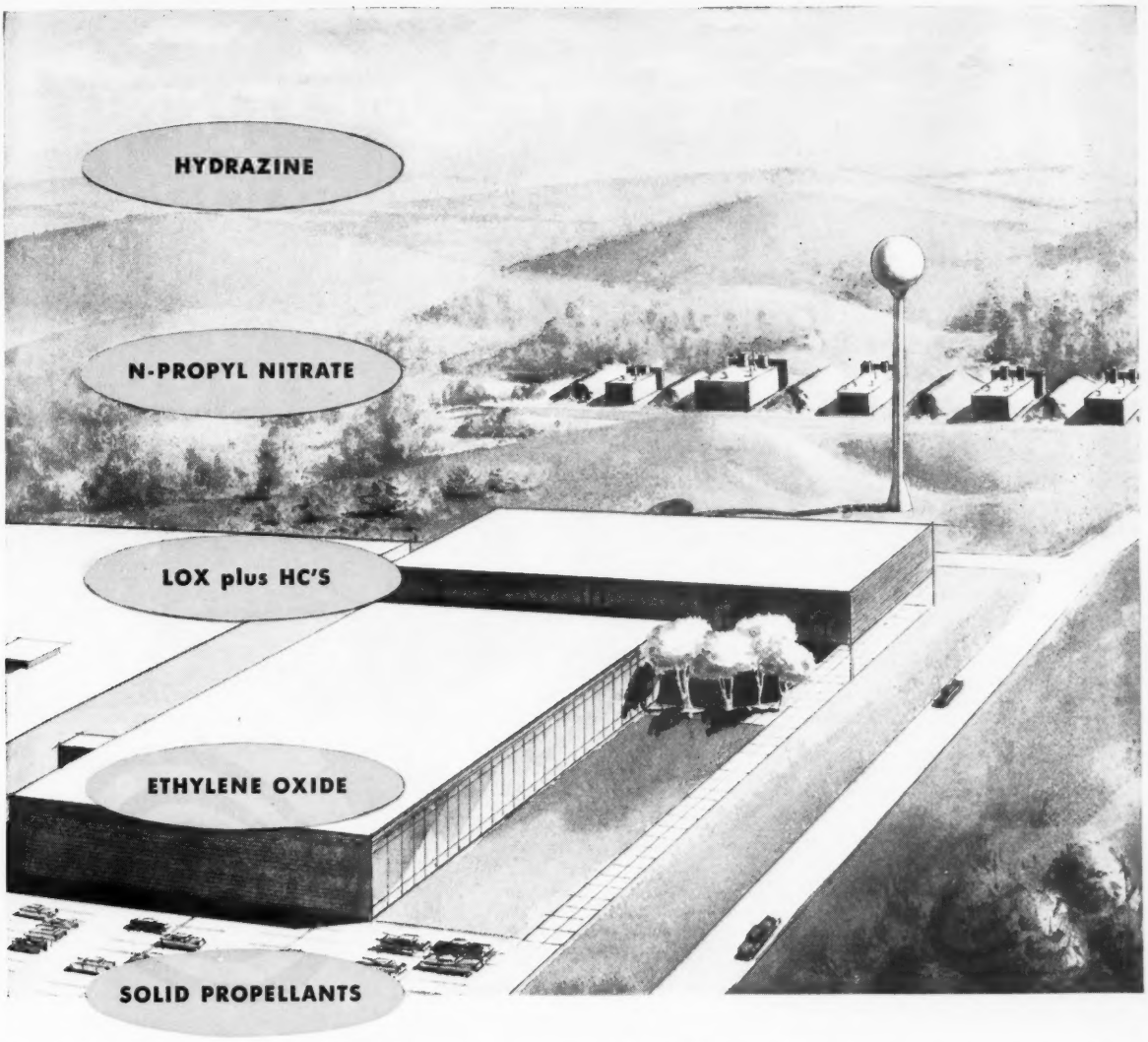
Services, material and facilities to manufacture, assemble and test mobile tracking units, $62,936, **Los Angeles Automotive Works, Inc.,** 1020 Towne Ave., Los Angeles.

Telemetering services and necessary equipment, $51,187, **Pacific Div., Bendix Aviation Corp.,** 11600 Sherman Way, N. Hollywood, Calif.

Naval Training Center, Pt. Washington, N. Y.

Design, develop and fabricate internal weapons simulators, Device 48A8, Contract N61339-174, $33,823, **Allegany Instrument Co.,** Cumberland, Md.

Design, develop and fabricate radar simulation system, Device 21B52, Contract N61339-182, $51,248, **Smith-Meeker Engineering Co.,** New York, N. Y.



In this new lab, these new fuels will be harnessed

Aircraft and missile fuel systems and auxiliary power units using high-energy fuels and nuclear coolants will be designed, developed and tested by the Accessories Division at this new test center now under construction on a 1000-acre tract in Franklin County, Virginia.

Precision Engineering...
Facilities...Quality

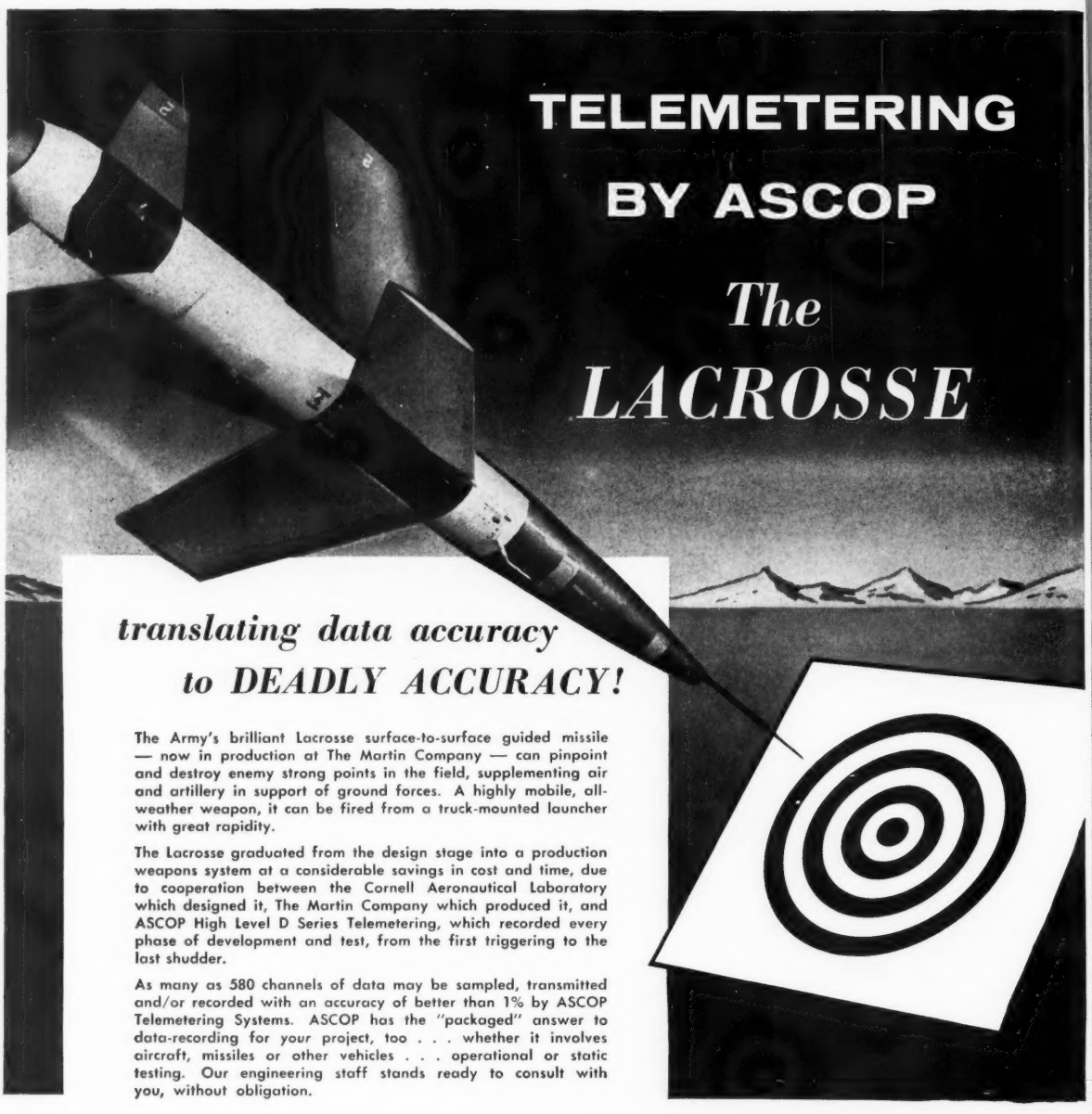
Challenging engineering jobs are available at the Virginia and Cleveland laboratories. Write to Dr. J. D. Stanitz, Chief Engineer, Accessories Division, Thompson Products, Inc., Cleveland 17, Ohio.

Accessories Division
Thompson Products
CLEVELAND 17, OHIO

Specialists in the design, development and manufacture of aircraft and missile fuel systems and pumps, small gas turbines, turbine-driven accessories, power packages, and nuclear-energy accessories and components.

TELEMETERING BY ASCOP

The *LACROSSE*

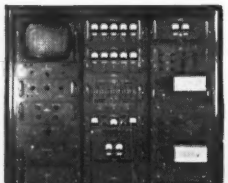


translating data accuracy to DEADLY ACCURACY!

The Army's brilliant Lacrosse surface-to-surface guided missile — now in production at The Martin Company — can pinpoint and destroy enemy strong points in the field, supplementing air and artillery in support of ground forces. A highly mobile, all-weather weapon, it can be fired from a truck-mounted launcher with great rapidity.

The Lacrosse graduated from the design stage into a production weapons system at a considerable savings in cost and time, due to cooperation between the Cornell Aeronautical Laboratory which designed it, The Martin Company which produced it, and ASCOP High Level D Series Telemetering, which recorded every phase of development and test, from the first triggering to the last shudder.

As many as 580 channels of data may be sampled, transmitted and/or recorded with an accuracy of better than 1% by ASCOP Telemetering Systems. ASCOP has the "packaged" answer to data-recording for *your* project, too . . . whether it involves aircraft, missiles or other vehicles . . . operational or static testing. Our engineering staff stands ready to consult with you, without obligation.



M SERIES GROUND STATION

ASCOP DATA REDUCTION EQUIPMENT

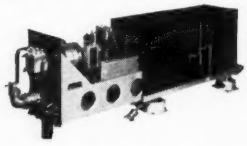
ASCOP Pulse Width Ground Station equipment complements ASCOP PW Multicoders and radio telemetering sets to provide complete "packaged" systems for operational testing of aircraft, missiles and other vehicles and for static testing of engines, rockets, nuclear reactors, etc.

MC-1 MONITOR CONSOLE GROUP

ASCOP DATA ACQUISITION EQUIPMENT

"D" SERIES PW DATA EQUIPMENT

For aircraft, mobile or other applications where recovery or continued use is practical and where space and weight are not critical. Samples up to 43 data sources.



LOW LEVEL PW MULTICODERS

Provides super-sensitive low-level remote measurement of data from airborne vehicles. High input sensitivity, fast sampling rate, wide selection of data channels.

APPLIED SCIENCE CORP. OF PRINCETON

PRINCETON, NEW JERSEY

West Coast Office:
15551 Cabrito Road, Van Nuys, California
Southeastern District Office:
1 N. Atlantic Ave., Cocoa Beach, Florida

ASCOP

WE PROVIDE THE LEVER - YOU MOVE THE WORLD

COVER: *Lucite rods emit blue light on warm-up after having been irradiated at liquid air temperature by gamma rays of cobalt 60, demonstrating release of energy of frozen-in radicals and metastable excited states* (*see page 46*).

Astronautics

Tomorrow is today

With this, the first issue of a new AMERICAN ROCKET SOCIETY publication, ARS takes a further step forward in expanding the services it now offers its fast-growing membership.

The magazine is new; the name is not. ASTRONAUTICS is, in fact, the very same name used for years by the Journal of the Society. Its use for this publication is accompanied by a certain sense of satisfaction, born of the fact that it was only 12 years ago that the title was changed because of a feeling that it was a little too visionary for a sober engineering society.

Time, however, has a way of catching up with forward-looking people. Today's visionary often turns out to be tomorrow's man of vision. In rocketry in the past 12 years, tomorrow has become today, and we now stand on the threshold of a new era—the age of astronautics, or flight through airless space.

Such flight for military purposes has been with us since the last war, and an ever-growing fraction of our more important weapons actually consists of space vehicles.

The AMERICAN ROCKET SOCIETY has as one of its main purposes the promotion of better understanding of the vast potential of the rocket in this new era, initially for scientific and military uses, and later for our day-to-day business.

In this program, ASTRONAUTICS will play a major role. It was born out of the demands of ARS members for a general interest magazine which would supplement the research and development material provided in JET PROPULSION while maintaining its sister publication's long-standing reputation for scrupulous scientific accuracy.

ASTRONAUTICS will provide ARS members with complete coverage of the rapidly expanding rocket, guided missile and propulsion field. Each month it will offer feature articles by outstanding authorities on subjects in which members have expressed interest, as well as complete information about important technical developments, news events and ARS activities.

It will, in short, be *the* publication in the field. As such, it will help bring "tomorrow" that much closer.

Robert C. Truax

PRESIDENT, AMERICAN ROCKET SOCIETY

ICBM: Giant step into space

Here, for the first time, is an authoritative account of the entire AF long-range ballistic missile program, its relation to past and future developments in terms of management and technical know-how, and an explanation of how it can make the conquest of space a reality

By Simon Ramo

THE RAMO-WOOLDRIDGE CORP., LOS ANGELES, CALIF.

Powerful lights transform Atlas test tower into contemporary etching in steel in this night shot of Convair's Sycamore Canyon test complex near San Diego, Calif. Base is one of three Convair employs to test ICBM's.

THE long-range ballistic missile program of the United States Air Force represents the largest integrated technical development program ever attempted by this country. It involves a simultaneous extension in practically every phase of the guided missile art. Compared with previous developments, it means higher thrusts, larger weight-to-structure ratios, higher speeds, higher accuracy and greater versatility in guidance and control, higher rates of burning of propellants, higher temperatures and greater expansion of facilities and industry capability in a short time.

The purpose of this article is to discuss, as security restrictions permit, some aspects of the USAF intercontinental ballistic missile (ICBM) and intermediate-range ballistic missile (IRBM) projects. In particular, an effort will be made to relate these developments, in terms of management and organization, as well as scientific-engineering concepts and actual hardware, to past and future developments in the missile field.

The Air Force ICBM program has a decade of background. The decision to broaden the effort and give it top priority was made in recent years, but development began some ten years ago at Convair Div. of General Dynamics Corp. During that period, scientific feasibility and military requirements were in proper harmony in a relatively small program looking to the fairly far-off future. Then changes in both the technical art and military needs combined to dictate an unprecedented effort to obtain the earliest operational capability.

Characteristics of Guided Missile Development

But there is a decade or more of guided missile experience covering a multitude of other projects as well, some of which have become operational. It will probably be helpful to summarize some general characteristics of guided missile development apparent when the accelerated ICBM program was planned, before discussing management and engineering details applying to this specific program.

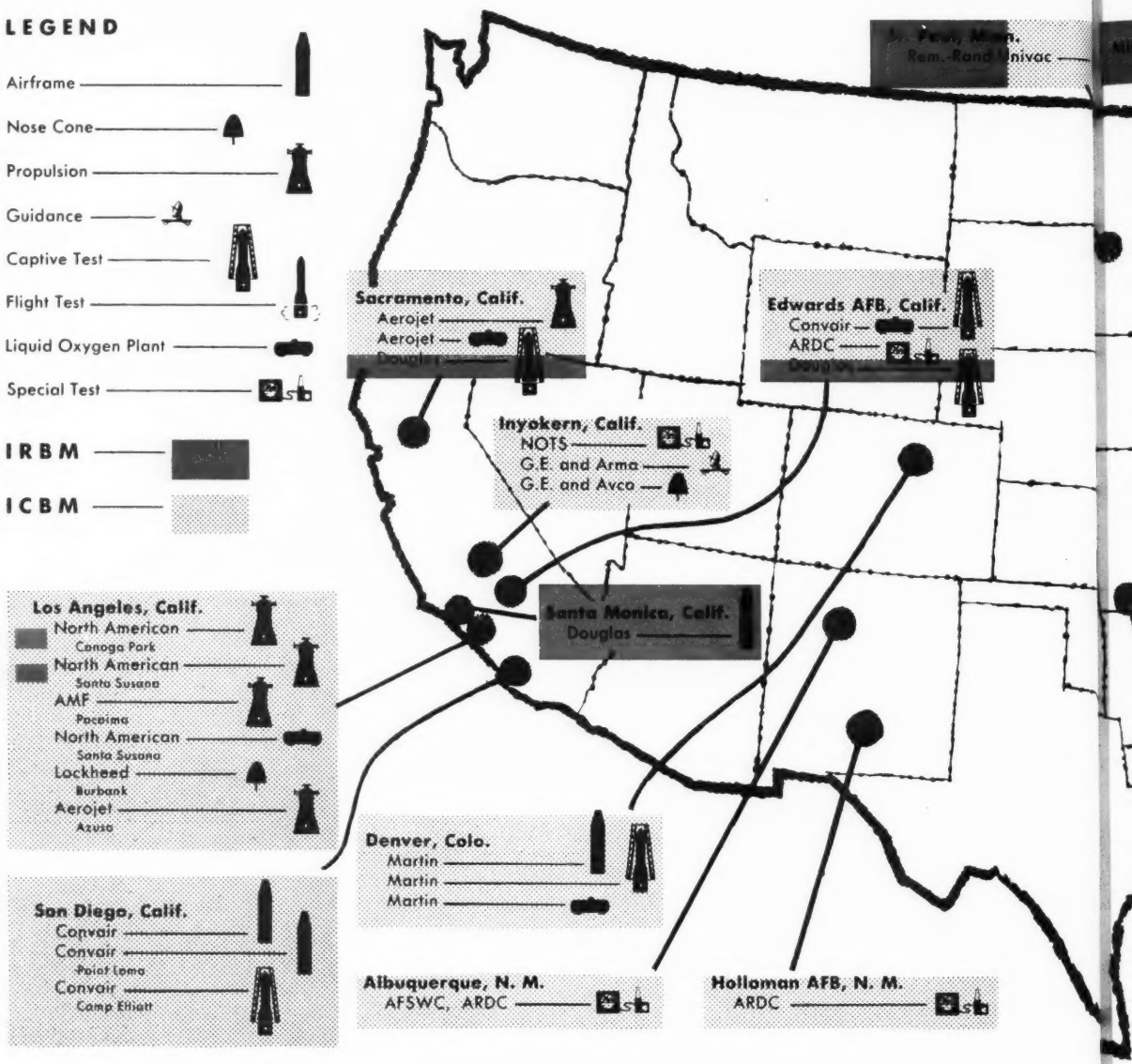
Of course, it is clear that a program of this type must include a large technical effort to develop and design all the components. And, for such development work to be completed satisfactorily, hardware must be built and tests made that confirm the workings of the entire system. What has been less than completely obvious in some past developments is the extent to which the whole developmental plan must hinge around certain practical factors.

The research and development plan must be based on careful matching of military requirements and the state of the art. The easy approach is to assume, from some "semi-hunch," qualitative considerations, both the military requirements and the supposed state of science and engineering. A more difficult approach, but one which can literally save years in attaining a useful end result, is to recognize that both the military requirements and the technical art are complex issues requiring careful interpretation and the consideration of many parameters on a quantitative basis, with full account of their reciprocal effects. To obtain a real payoff in time

The nation's super-priority intercontinental ballistic missile program is also its largest guided missile effort. Systems engineering and technical direction for this vast undertaking, as well as for the intermediate-range ballistic missile program, have been entrusted to The Ramo-Wooldridge Corp. by the Air Force. Simon Ramo, the author of this article and the company's executive vice-president, serves as the "Chief Scientist" of the ballistic missile program.

To provide an authoritative account of the ICBM program, ASTRONAUTICS invited Dr. Ramo to prepare this article, the first of its kind to be released and the first article on the over-all program prepared by a member of its technical staff.

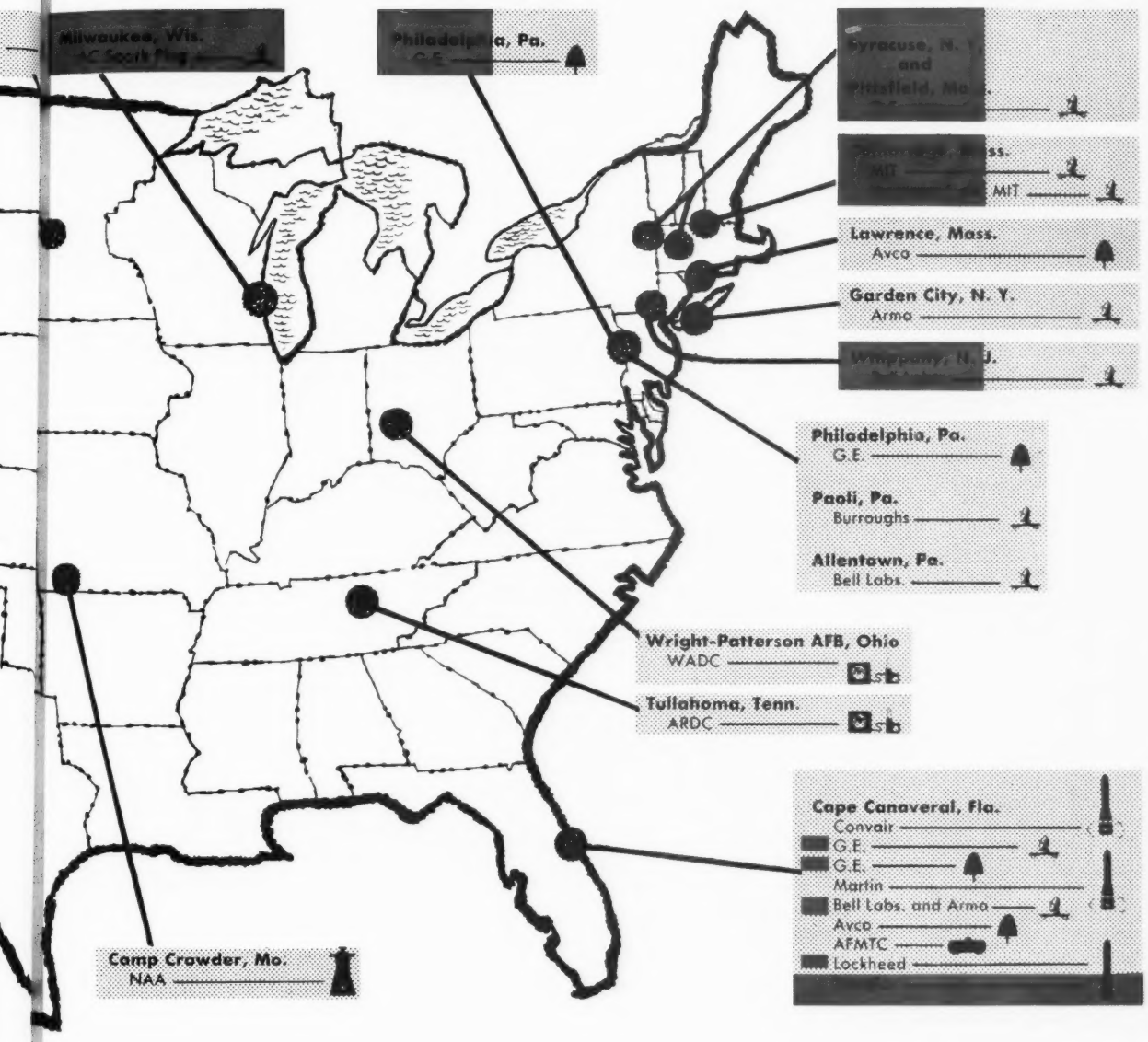
ICBM and IRBM Facilities



and resources, the task must be faced up to by a proper team of military and technical experts brought together for steady and objective influence on the research and development plan.

The picture of a guided missile program in which only one missile is assembled and taken out to launch, with the chief scientist and his sole assistant waiting with high hopes for a confirmation in final flight test through this single definitive trial, is for the comic books, and not for a realistic world. A single or a few shots of a missile, built breadboard fashion by its inventors in a closely supervised model shop, may be a satisfactory approach to illustrate a principle. More often, in guided missile development, the step being taken from the technical standpoint is essentially beyond question as to its scientific basis. The key problem is to so organize the program as to assure the efficient working out of all the engineering details, some by theory and some by experiment; the attainment of reliability through a great deal of testing; and an industry capability to reproduce the results in the quantities required for a military force.

How early production planning can be started is special for each guided missile project. It is a function of the newness and complexity of the engineering and the relative risk of having a delay while production is planned after the development

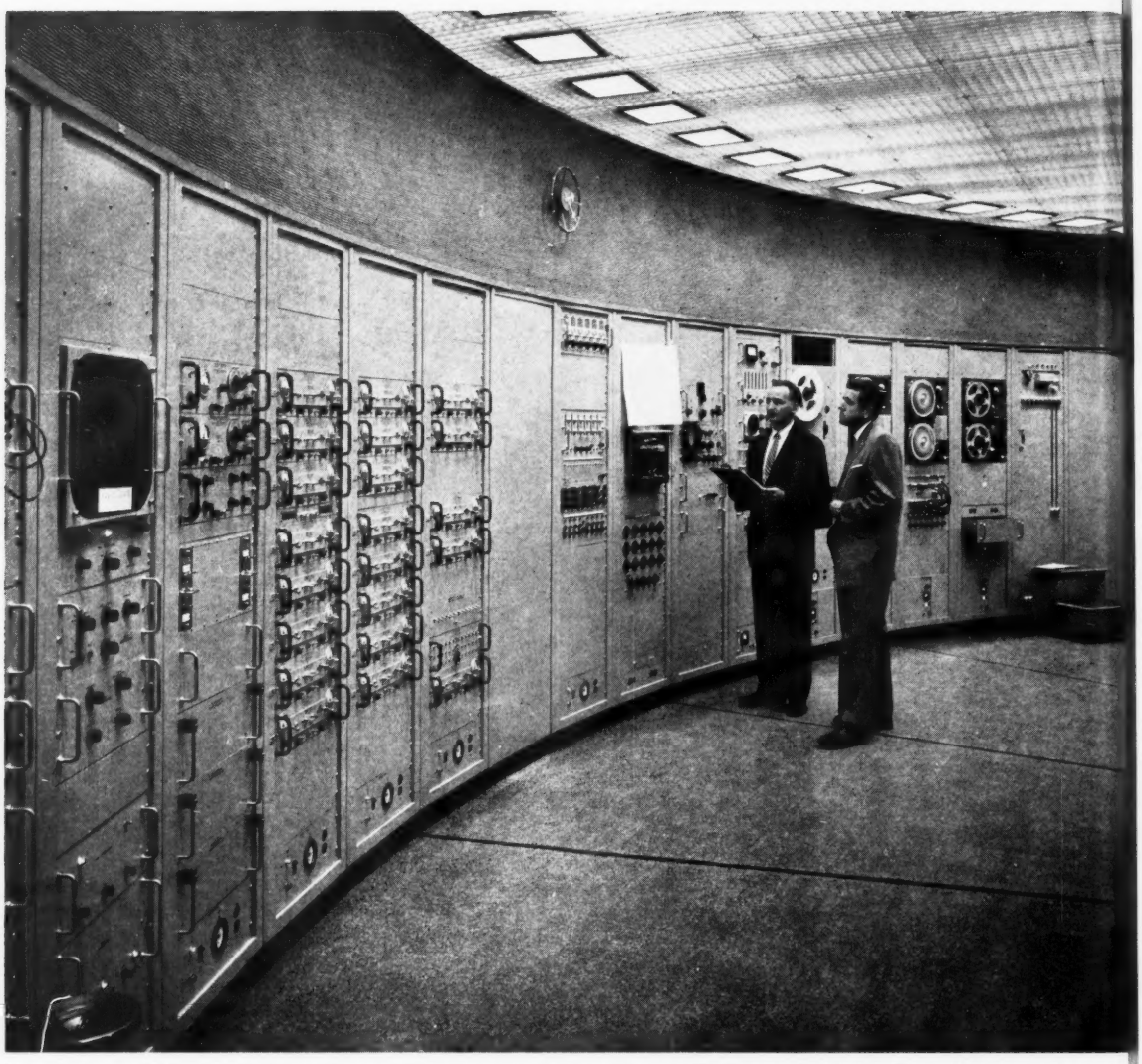


is completed, as against having to re-do production tooling or manufactured components if the late stages of development disclose that substantial engineering design change is needed. However, in any case, it must not be overlooked in the development of a missile that production and operational capability are the real end goals of development.

In the past, reliability considerations have not been in the foreground often enough. Clearly, a complete missile system cannot be very useful in a national emergency if it is likely to fail in some important respect more than a small fraction of the time. But the complete system consists of many major subsystems, including, of course, much more than the vehicle itself, creating further problems

Suppose we ask for a modest 50 per cent chance that the complete system trial will occur without a malfunction of some major subsystem. For simplicity, let's say there are five or six of these main subsystem elements, with an equal chance that one of them will function improperly during flight. Then, to have a 50 per cent chance for a completely successful flight, each of these subsystems must be counted on for roughly a 90 per cent chance of operating perfectly.

But each of these subsystems itself consists of hundreds of critical components, which must then have an average reliability during flight in the 99.9



The author (left) and an associate in the Data Reduction Center at Ramo-Wooldridge. Here, highly technical ballistic missile data is expertly analyzed as it comes from test facilities throughout the country.

per cent region, with a failure of only one in a thousand. Even if each of these components is laboratory tested, improved and retested innumerable times, this must be followed by systems testing to determine the interactions of one component on another when working in an ensemble, and then by flight test because of possible reduced reliability owing to environment and unknowns in actual flight that no prior simulation or analysis can dependably reveal.

Cannot Rely on Flight Tests Alone

Typically, missile flights are measured in minutes. A flight-test program, especially in its earlier stages, reveals only fragments of data for various parts of the complete trajectory. Hundreds of flights may be needed to accumulate a single hour of operating experience. It is apparent that the attainment and the proof of reliability, somewhat different considerations, cannot rely on flight test alone, because of the enormous expense and the relatively small amount of data obtained. Wherever possible, all subsystems must be brought to high reliability by ground tests. The complete systems test must be used for that class of problem in which interactions among all parts of the system and the true environment of flight are the added problems.

This does not mean that the first flight test should be delayed until testing on the ground has caused all elements to reach a stage of reliability where nothing remains but these final interactions and

environmental problems. Flight testing in its initial stages obviously is carried out to uncover interaction and flight environmental problems as early as possible, even if it is a virtual certainty that the first flight tests will be handicapped by unreliability of components.

Thus, the final "ground" development of all subsystems and components for the goal of a successful operational flight depends partially on the results of earlier imperfect flights. Complete systems tests, including missile launchings, constitute the only way ultimately to completely confirm the soundness of system design. But the first flight tests are so likely to be plagued by the accumulation of many detailed shortcomings of the whole operation that they might mask a fundamentally wrong system configuration, if such a misconception in design philosophy actually existed.

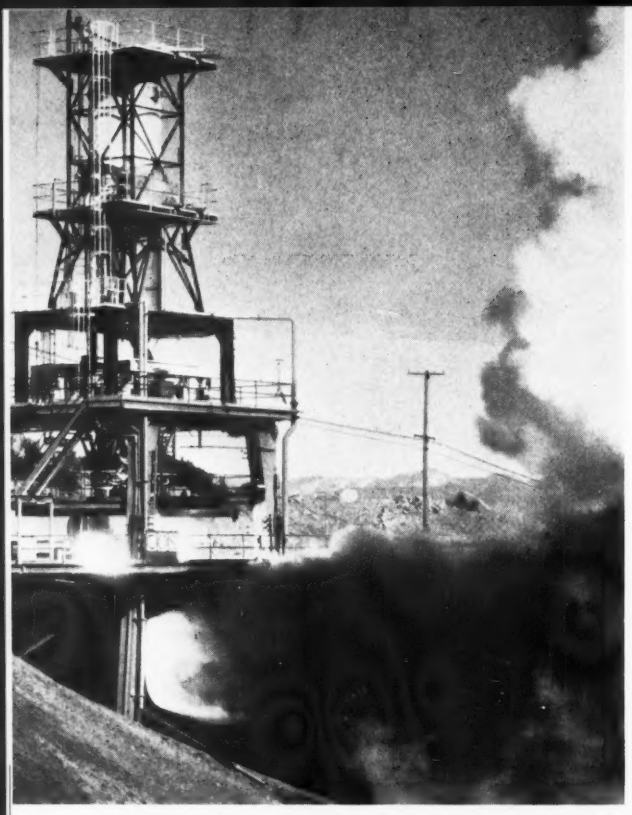
Reliability and 'Good Design'

The important lessons from the past include the fact that reliability does not come naturally as the result of "good design." An engine will not provide a specific thrust just because it is well designed. It must be designed for that specific thrust. And no matter how well designed for 1000 lb of thrust, it is not likely to give 100,000 lb unless so grossly overdesigned as to constitute a poor engineering choice for the original requirement. Similarly, a particular component is not going to give 99.9 per cent reliability unless it is designed for that from the beginning, and we are not going to know whether it has that reliability unless we have a planned program to prove it.

Programs of the past have included some that have lacked sufficient hardware to make possible any satisfactory approach to reliability testing. Other programs have been so optimistic as to the number of units of the system that could be used to advantage that they suffer from indigestion, with shops busy making parts whose workings have not been sufficiently well understood and whose test program, both as to technical manpower and facilities, was inadequate to make use of the hardware as a means for finding design weaknesses. Planning the amount of hardware for each stage of the program, from the beginning of component development and reliability checkout through to final systems testing and initial operational capability

X-17 blasts off on its journey into space from Patrick AFB, Fla. The re-entry test vehicle is built by Lockheed's Missile Systems Div. in Van Nuys, Calif.

Brig. Gen. O. J. Ritland, vice-commander, AF Ballistic Missile Div., breaks earth for $100-million construction project at Cooke AFB, Calif., where officers and men will be trained in launching ICBM's and IRBM's. Looking on is Col. David Lyster, Cooke commander.



Test firing of large liquid rocket engine under development for AF ballistic missile program at Santa Susana, Calif., facility of Rocketdyne Div. of North American Aviation.

for military use, is a major factor in setting up and maintaining a good development program for a major missile system.

There is probably no characteristic of major weapon systems programs that has so often in the past been the determining factor in the speed and efficiency of development than the facilities program. The tendency all too often is to fail to include all needed facilities, or to underestimate the lead time required and the technical difficulties of such facilities programs. Major facilities acquisition also involves difficult arrangement-making problems between various government agencies and between such agencies and industrial contractors. Recognition of the size, scope and complexity of facilities problems is a prime requirement for the successful execution of a major program.

Tended to Focus Attention on Bird

During part of the decade now behind us, there was a tendency in some missile development programs to focus attention almost entirely on the "bird." In general, there is a myriad of other equipment that must be designed and other problems that must be dealt with to make for a military operation. Checkout equipment, handling and training equipment, organization of operational bases, logistics and human engineering factors—all are needed to complete the list. The design of this equipment and attention to the array of procedural and other problems that go with a complete weapon system cannot wait until there have been successful "demonstrations" of the flying subsystem. Obviously, it is not good systems engineering to freeze one part of the system until attention has been given the other parts. In addition, the desire for early operational capability means all parts of the system must be started early.

Nation's Resources Called Upon

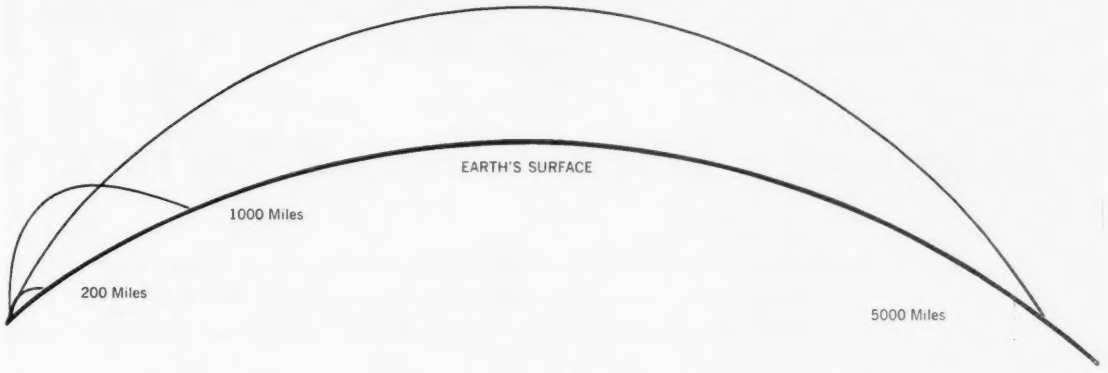
From the beginning of the accelerated ICBM program, it was evident that questions of management; philosophy of over-all approach and organization would need a special kind of attention. Moreover, the total effort, if carried out successfully in a relatively short time, would involve a costly fraction of the nation's scientific and material resources. The simultaneous advances required for the present program in all aspects of guided missile system art made clear that large facility, hardware and reliability testing programs would be needed. It was obvious that the entire program would have to be widespread geographically and would require contributions by large numbers of organizations. It would also have to be unusually well organized and highly supported on a good management, as well as scientific, base. These operations could not be left to trial-and-error or hit-or-miss experimentation.

Certainly few, if any, programs have had and continue to have the advantage of a deeper study of the relationship between military requirements and technical possibilities. Time, performance and resources compromises are always necessary in merging a military need with technical and industrial attainment. But in the present instance, it simply has had to be a lot better. Top military and technical minds of the country have been joining to create and maintain research and development, production and operational plans with the least doubts as to the fundamental soundness and proper timing for each step.

Of course, any program comprising a vast number of interrelated steps cannot be precisely laid out ahead of time. Moreover, some steps must depend on progress or data obtained in earlier ones. But the objective has been to plan a program that will have a minimum chance of hinging upon any greatly speculative technical issue, and, equally important, upon any questionable evaluation as to the ability to carry out development and production as required.

A fundamental part of the plan for the earliest

RELATIVE TRAJECTORIES OF 200, 1000 AND 5000 MILE BALLISTIC MISSILES



possible attainment of both long- and medium-range ballistic missiles has been to make maximum use of all past developments in technology, as well as all of the nation's existing facilities. For essentially every important aspect of the over-all program, it has been clear that more than one approach is technically and industrially feasible. However, to predict which of these potential approaches would lead to the others timewise is not always possible. Also, the importance of the program requires insurance against errors in human judgment. For both of these reasons, a certain minimum number of parallel approaches was considered essential in most areas.

But there was still another reason for bringing in two major contractors to cover independently most basic subsystems—namely, the amount of effort needed for detailed design, testing and production planning. This huge work load—the different types of ballistic missiles to be developed, the numbers and kinds of needed facilities, the locations of various industrial organizations with respect to areas suitable for testing subsystems and to long-range testing bases—all made clear that for almost every aspect of the job it would be necessary to bring in more than one top organization to share the load. The division of the work was made among a large number of industrial organizations, government agencies, universities and private foundations, all selected by the Air Force and assigned to specific program segments on the basis of their experience and their technical, physical and management resources.

STEP-BY-STEP INTO SPACE

RANGE (naut. mi.)	ALTITUDE AT APOGEE (naut. mi.)	CUT-OFF OR ESCAPE VELOCITY (ft./sec.)
200	70	3,000
1,000	350	11,500
5,000	600	22,000
Satellite	(300)	25,000
Moon	–	35,800
Mars (Optimum traj.)	–	36,500

How Missile Teams Were Selected

With duties in ground-support equipment, training and handling added to the production effort, and all having to be started prior to the completion of the research and development program, it was seen to be advantageous to select for key development projects those organizations in the nation capable of continuing through to production and operational equipment support. More specifically, it was felt that team members that would ultimately dominate factory testing of production articles to be delivered to operational units should be the ones to make the first experimental tests on embryo equipment.

Separate teams were set up for three missiles, with the three aircraft team members (Douglas on Thor (IRBM), Convair on Atlas (ICBM) and The Martin Co. on Titan (ICBM)) given the jobs of physical integration of the subsystems into the missile structures and systems testing. The setting-up of these three projects has been an efficient way of combining the need for a certain minimum of back-up approaches with the equally important requirement of assuring tight integration of subsystem tasks into a harmoni- (CONTINUED ON PAGE 83)

An industry leader looks at the future

Dan Kimball's crystal ball indicates enormous expansion of rocket business during next five years, one-hour coast-to-coast flights by rocket-powered aircraft, and major technological breakthroughs

By Dan A. Kimball

AEROJET-GENERAL CORP., AZUSA, CALIF.

Dan A. Kimball is a World War I Army pilot whose lifelong interest in aviation has led him to the presidency of Aerojet-General Corp., as well as high government office. Mr. Kimball joined General Tire and Rubber Co., of which Aerojet is a subsidiary, in 1920, and in 1944 became a vice-president of the rubber company and executive vice-president and general manager of Aerojet. He served as Secretary of the Navy from July 1951 to January 1953, after previously having been Assistant Secretary for Air and Under Secretary.

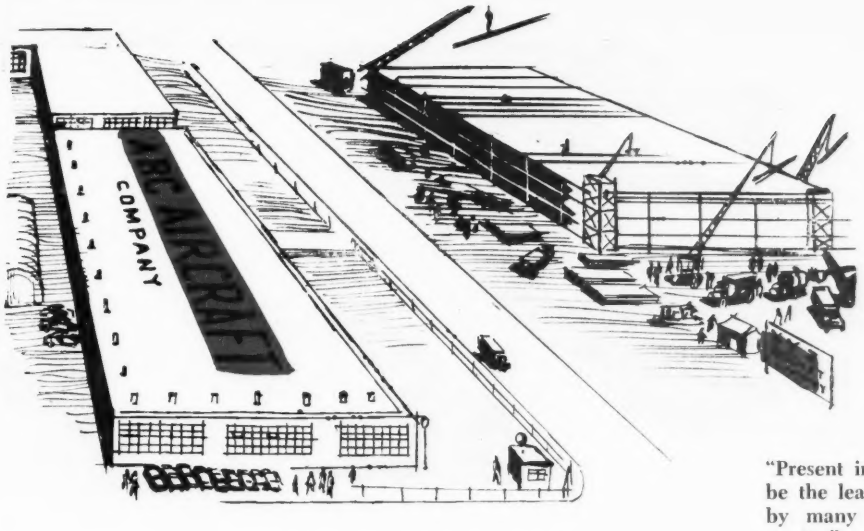
IN THE United States, the ancient art of rocketry and the skills of modern industry were joined together only 15 years ago. That union created the rocket industry. Ever since that day I have been part of it as a businessman, and I believe I have a pretty good idea of what has gone on in it. In fact, I hope I have a fairly clear view of how the industry stands at present. However, when the editor of this new publication of the AMERICAN ROCKET SOCIETY asked me to outline what the position of the rocket industry will be in 10 or 15 years, I had a feeling he might be leading me into a malfunction.

History remains our fairest guide to the future, but I am sure that a man who 15 years ago used the light of history to detail the state of the rocket industry today would find himself eating a great many words. When I went into this business, there was a considerable number of men, some of them my scientific and engineering colleagues, who foresaw much of the technical development that has come since. World War II still was in progress when they knew that an orbiting earth satellite was feasible. They told me how it could be made and launched; all that was necessary was that the metals and propellants be invented and developed, as they have been since then.

None of those men, though, dreamed that within 15 years companies then placidly milling wheat or extruding plastics would occupy important positions in rocketry. Nor would they have ventured to say that within such a short time substantial doubts would have arisen as to whether military aircraft now on the boards ever will be flown because pilots are nearing obsolescence.

To me, the growth of the rocket *industry* to its present proportions is quite as astonishing as the technical progress made in pilotless flight. So far, the industry isn't well enough and separately enough organized to compute its size accurately. But most of its business is done on government contract—unfortunately, nobody just walks up and buys a rocket—so the volume of appropriations gives some indication of the over-all dimensions of the industry in a given year.

In the President's budget for 1958 the figure for spending and



"Present industry leaders will still be the leaders, but will be joined by many healthy younger companies."

authorized obligation, including research and development, is $2,978,000,000 for missiles. Not the largest industry, of course, but by no means small, and without question the fastest growing. The figure given above is just about twice the comparable figure for 1956.

Obviously the rocket industry is not going to double every two years. It cannot maintain that rate of acceleration. But certainly I expect to see it continue to grow at a pace which in any other business would be phenomenal. The number of companies now depending substantially on rocket development and manufacturing is beyond guessing, but it runs into the thousands. Some are extremely large—the airframe manufacturers, for instance. Others in great number conduct relatively small research and development projects or manufacture specialized components.

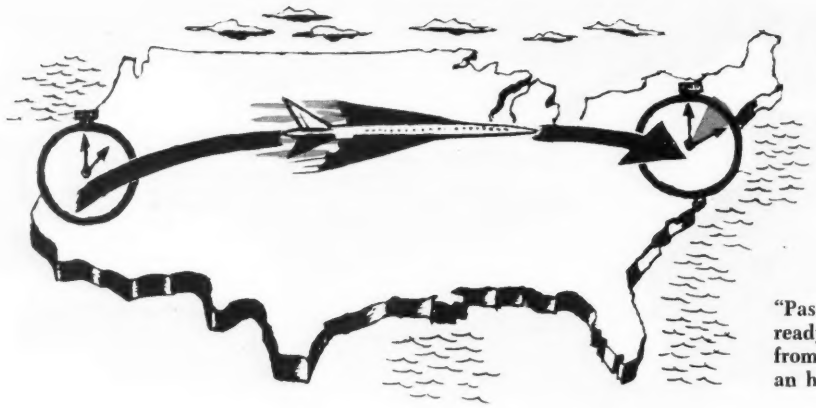
In fact, the rocket industry has spread so widely that it touches every part of the nation's economy. Further, the influence of rocketry is felt directly in the lives of almost every one of us. To some extent it sways our educational directions, colors our personal plans, enters our daily thoughts, and governs our hopes for a safe and peaceful future.

Changes Have Been Vast in Past 15 Years

The rocket industry has not only become large; it has become incredibly complex. The changes have been vast since the day, which seems to me only a short time ago, when I induced the firm I worked for, the General Tire and Rubber Co., to invest in a small company in need of capital and business management to produce the numbers of primitive JATO units the Navy wanted in 1942.

The future of the rocket business depends, like that of all businesses, on what it produces. The course of the next few years will see the production of extraordinary things now on the drawing boards, or at least floating in men's minds. Experience has taught me to believe that scientists and engineers ultimately will succeed in getting into the air what they are now putting on paper.

"Dollar volume will expand tremendously for the next several years."



"Passenger planes using engines already under development will fly from Los Angeles to New York in an hour or so."

I have become accustomed in the past 15 years to seeing men produce what seems to me miraculous, but to be assured that ion propellants are just around the corner, and that other even more unlikely means of propulsion are not far off, may well make any man reluctant to prophesy.

The prophet in this business usually is too conservative, and 15 years in the future is a long time in an industry with a past that is only 15 years old.

Naturally, there are certain things I expect to see eventuate. I have some ideas about the industry's general direction, of course. As a businessman, it is part of my trade to listen and peer ahead. So, thrusting my neck out and asking gentle readers to bear in mind that in this business everything comes step by step, I expect that within 15 years:

Piloted aircraft, both civil and military, will be useful only for transportation of passengers and freight.

Passenger planes will fly from Los Angeles to New York in an hour or so, block to block. Engines embodying rocket principles are already under development. Some have even had tests on stands, and could be ready within five years to accomplish this.

I expect to find present leaders in the industry, including airframe and engine manufacturers that have turned to rocketry, still the leaders, but with many healthy younger companies coming along and older companies expanding into our field.

Dollar volume will expand enormously for the next several years. After that, international political factors now impossible to predict, rather than technical feasibility, will determine the industry's size and growth.

Technical breakthroughs, in propellants, metals, guidance and especially in plastics, are nearer than we think. Of these, I anticipate the most sweeping results from propellant development.

Optimism is hardly a strong enough word to describe my attitude toward the future of our business. I have seen the industry grow to its present state from very small beginnings in a short period of time, and I feel that we're still only on the verge of a rocket age.

I'm glad I am part of it.

"Technical breakthroughs in propellants, guidance and structural materials are nearer than we think."

Propellants for tomorrow's rockets

Scientists turn their attention to use of the light metals, frozen free radicals and metastable states, radioactive isotopes and nuclear energy in their search for the ideal fuel

By Fritz Zwicky

CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF.

SCIENTIFIC *forecasting* can in principle accurately predict future events, but *prophecy* must rely on imagination. While prophecy in human affairs is risky, it has a fair chance of correctly visualizing the evolution of technology into quite a distant future. Prediction of technical progress is greatly aided through the use of morphological thinking, the systematics of which are described in the author's book on "Morphological Astronomy," Springer-Verlag, 1957. In this look at future rocket propellants, an abridged form of the morphological approach has been employed, starting from certain pegs of knowledge about conventional propellants and systematically infiltrating and exploring the fields around them.

Desirable Characteristics of Propellants

Restricting ourselves for brevity to jet engines traveling either in vacuum or in the tenuous gases of the upper atmosphere, some desirable characteristics of propellants may be listed as follows:

1. High energy content ϵ_m per gram of total propellant, especially if this energy can be released at any rate desired.

2. The reaction products generated during the release of ϵ_m should be largely gases which have a high gamma γ ratio. For monoatomic gases, this ratio is 5:3, the highest value possible.

3. If ϵ_m is not uniformly distributed over all the elementary particles which constitute the reaction products, but resides mainly in gamma and beta rays, rather than in the remaining atoms, ions and molecules, grave difficulties arise if one is to achieve high propulsive efficiencies, and a very sophisticated jet must be envisaged.

4. The rocket should carry a minimum of propellants, picking up working fluid and freely available energy from the surrounding medium (principle of the interplanetary aeroduct).

5. In some cases, Condition 1 must be replaced by the requirement of optimum energy content ϵ_v per unit volume. In this case the parameters γ and ϵ_v cannot be independently optimized, as a fundamental theorem developed by the author demonstrates. This theorem states that, for any conventional chemical reaction, starting

Fritz Zwicky is professor of astrophysics at the California Institute of Technology and staff astronomer at the Mount Wilson and Palomar Mountain Observatories. After obtaining his Ph.D. in physics and mathematics in Zurich, he came to this country and was international research fellow and assistant professor and associate professor of physics at Cal Tech from 1925 until 1942. He was director of research for Aerojet Engineering Corp. from 1943 to 1949 and is now chief research consultant of Aerojet-General. He was also recently named scientific adviser to Hycon Mfg. Co.

Lucite rods, originally irradiated at liquid air temperature by gamma rays of cobalt 60, emit sufficient light on warm-up to permit print to become legible in darkened room.

from standard pressure and temperature (SPT), ϵ_v is less than 3 kcal/cm³ of reagents, provided that all of the reaction products are gaseous, or even partly liquid, at SPT. Only if some of the reaction products are solid at SPT can ϵ_v become greater than 3 kcal/cm³.

Henceforth, we shall principally visualize the realization of ever higher values of ϵ_m and of ϵ_v, without being concerned with the supplementary criteria which determine the ultimate value of any propellant. But these must be kept in mind if actual jet engines of the highest thermopropulsive efficiency are to be designed.

If all of the energy ϵ_m in one gram of propellant could be converted into translational energy, the reaction products would assume an exhaust velocity u equal to $(2\ \epsilon_m)^{1/2}$ relative to the combustion chamber. For conventional propellants, ϵ_m is of the order of 1 kcal, or 4.17×10^{10} ergs. Therefore, u is of the order of 2.5 km/sec. The performance of a propellant is often expressed by the specific impulse $I_{sp} = u/g$, where g is the acceleration of gravity. I_{sp} for good conventional propellants thus is of the order of 250 sec.

Rocketry availed itself at first of compounds containing carbon and hydrogen as fuels, oxygen as the oxidizer and, occasionally, of nitrogen as an inert ingredient. The story of the conventional propellants therefore is told by the following data:

1. The reaction C (amorphous) + O_2 (liquid) = CO_2 releases ϵ_m equal to 2.08 kcal/gram and ϵ_v equal to 2.67 kcal/cm³.

2. The reaction 2 H_2 (liquid) + O_2 (liquid) = 2 H_2O releases ϵ_m equal to 3.60 kcal/gram and ϵ_v equal to 1.52 kcal/cm³, in agreement with the upper limit described above.

Reaction 2 requires the storage of propellants at very low temperatures. Both Reactions 1 and 2 lead to triatomic gases, whose gamma ratios are low, approximately equal to 1.30 at SPT and much lower at the high temperatures in combustion chambers. In practice, an unfortunate compromise must therefore be struck, burning part of C to CO only and not burning some of the hydrogen at all.

Solutions for the 'Carbon Dilemma'

In searching for better propellants, morphological field coverage takes its start from the difficulties just mentioned. The following solutions suggest themselves for getting away from the *carbon dilemma*, which has its origin in the competition between the two oxides CO and CO_2, in combination with the vicissitudes of the water gas equilibrium CO + H_2O = H_2 + CO_2:

1. Drop C entirely and substitute atoms such as Li, Be, B, Mg, Al and Si instead. If we compare the heat of combustion of B with that of C, we find per gram mole values of CO, CO_2 and B_2O_3 to be respectively 26.84, 94.45 and about 300 kcal, or, per gram of the original reagents (C or B plus O_2), 0.96, 2.16 and 4.30 kcal.

To achieve high gamma values, free H_2 in the exhaust is most useful. Hydrocarbons of the approximate type $(CH_2)_n$ pack hydrogen in the weight ratio of 0.17, while for B_2H_6 this ratio is much more favorably equal to 0.28.

In elaboration of the reasoning just given, the present author, in collaboration with J. M. Carter, in 1943 initiated the introduction of fuels like Al $(BH_4)_3$ and the systematic exploration of combined light element hydrides and nitrides for use not only in straight rockets, but in aerial and hydrojet engines as well. For rocket propellants, specific impulses of the order of 300 to 350 sec thus became possible.

2. We may retain C partly, while introducing Li, Be, B, etc., as the main fuel constituents. Our thoughts thus turn to the possibility of C $(BH_4)_4$ as one of the most attractive fuels. While it is as yet undecided whether this fuel can be made, other combinations of C, H, B and perhaps N can be achieved which constitute fuels more powerful than the hydrocarbons.

3. If we insist on retaining carbon as such, we

may possibly overcome the previously mentioned difficulties attaching to this element by eliminating its conventional associations with hydrogen and with oxygen as the oxydizer. This leads to the startling observation that the condensation reaction of C (gaseous) into C (solid) liberates 15 kcal/gram, which is about four to ten times the heats of reaction available in conventional propellants.

It may thus be predicted that the use of "completely" amorphous carbon, or of "polymerized" C_2, will actually make available a good fraction of the enormous heat liberated in the condensation of carbon. For use in rockets, these reactions must be coupled with compounds liberating maximum amounts of gases.

4. There is a possibility of more powerful oxidizers. With the introduction of fuels not containing any carbon, the use of fluorine is naturally indicated.

5. Significant improvements would seem possible through the introduction of monopropellants, nitromethane having been the first to be experimented with in this country by the research department of Aerojet Engineering Corp. in 1943. In the new fields of fuels which do not contain any carbon, a vigorous search for monopropellants appears particularly desirable.

Morphologically, monopropellants fall into two classes. The first is made up of molecules which can in principle explode individually. These molecules are, quantum mechanically speaking, *metastable*. C_2H_2 is an example. The second type of monopropellant, such as nitromethane, is made up of molecules which individually are absolutely stable. A multitude of these molecules, however, can explode, thus constituting a thermodynamically pseudostable monomolecular gas, liquid or solid.

Fragment Chemistry and Metachemistry

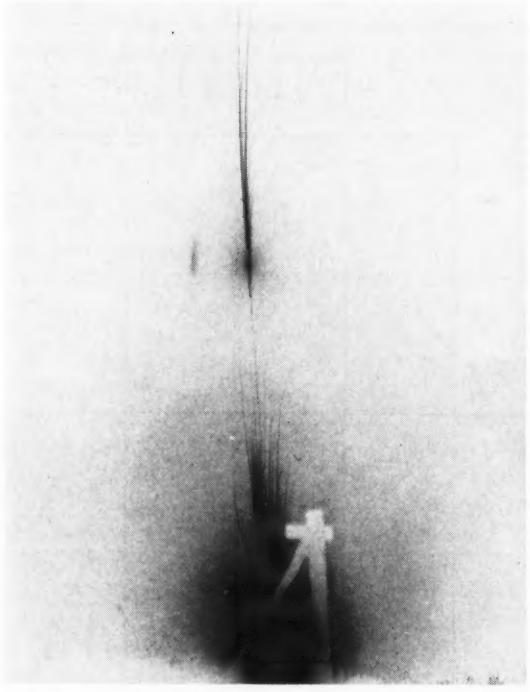
Starting from these notions of pseudostability and of metastability, the author proposed work on two new fields of science, for which he introduced the designations "fragment chemistry" and "metachemistry."

These proposals were first circulated in 1943 in internal reports within the Aerojet Engineering Corp. in Pasadena and were later published in *Chemical and Engineering News*, vol. 28, 1950, pp. 156–158, and other journals. Practical support for the realization of major issues on fragment chemistry and on metachemistry was first given the author and his associates at Aerojet by the Research and

One road being taken in the search for better fuels centers on the elimination of carbon as a fuel constituent and the substitution of such elements as lithium, beryllium, boron, magnesium, aluminum and silicon.

	0	I	II	III	IV	V	VI	VII	
		X¹ a H 1							
1	2 He 4	3 Li 6·9	4 Be 9·0	5 B 10·8	6 C 12·0	7 N 14·0	8 O 16·0	9 F 19·0	
2	10 Ne 20·2	11 Na 23·0	12 Mg 24·0	13 Al 27·0	14 Si 28·1	15 P 31·0	16 S 32·1	17 Cl 35·5	
3	18 A 39·9	19 K 39·1	20 Ca 40·1	21 Sc 45·1	22 Ti 47·9	23 V 51·0	24 Cr 52·0	25 Mn 54·9	26 Fe 55·8

Photos on these two pages show developments stemming from the author's attempts to produce self-luminous artificial meteors capable of escaping from the earth. Here, ultrafast particles, ejected with a velocity of 10 km/sec, are extruded detonatively from conical copper liner of shaped explosive charge. Plume of particles whose paths appear flattened out because of rotation of camera are fragments of charge container.



Ejection of ultrafast coruscative particles from shaped charge. Internal reaction in coruscative is ignited by detonative shearing stresses in coruscative inserts.

Development Command of the US Air Force through the grant of unclassified contracts.

Fragment chemistry deals with the study, production and stabilization in macroscopic density of molecular fragments, such as chemical radicals and ions. For use in both propellants and explosives, the value of radicals in high concentrations is obvious. For instance, the reaction $H + H = H_2$ liberates 51.9 kcal/gram, as compared with 0.63 and 1.51 kcal/gram for TNT and nitroglycerine respectively. While nitromethane, with ϵ_m equal to 1.06 kcal/gram for its heat of disintegration, is capable of producing a limiting specific impulse of about 300 sec, the reaction $H + H$ into H_2 gives a limiting specific impulse of 2160 sec.

To avoid the destructive temperatures associated with the realization of such performance in ordinary rocket motors, new types of conversion of chemical reaction energy into propulsive energy will be necessary. The as yet little explored isothermal (mechanical or electrical) conversion, as well as cooling through adiabatic extraction of electric current, will have to be considered. If the limitation of conventional rocket motors to temperatures lower than 3000 K is to be observed, these can, for instance, be accommodated by the following propellant systems, containing stabilized radicals and H_2 as a diluent:

(1) 2.2 moles H_2 plus 1 mole NH, with I_{sp} equal to 440 sec; or (2) 5 moles of H_2 plus 1 mole of CH, with I_{sp} of 510 sec; or (3) 1.7 moles H_2 plus 1 mole of H, with I_{sp} of 775 sec. (See Report 1219-1, Oct. 1, 1954 on unclassified OSR Project 474-000 at Aerojet-General Corp.)

These specific impulses are two to three times those currently achieved, and will make possible escape from earth with single-stage rockets.

What Metachemistry Is

Before going into possible methods of stabilization of radicals and of their use for propulsion, both in the condensed state and as they occur in the high strata of the atmosphere and in interstellar space, a few words on metachemistry are in order.

Metachemistry deals with the study, production and the use of quantum mechanically metastable particles, molecules or states of matter in general. Metastable states may be roughly grouped into the following three categories:

1. *Spin metastable* states such as orthohydrogen, which, as a single molecule, has an immense lifetime and which, even in bulk density and at low temperatures, converts only slowly into parahydrogen, liberating 0.337 kcal per gram mole of H_2. Orthohydrogen at very low temperatures therefore represents a *frozen-in* metachemical potential propellant.

2. *Electronically metastable* states of the type of those well known in O_I and O_{III}, "forbidden" transitions from which come the green auroral line λ5577 and the nebulium λ4958.9 and λ5006.8. Electronically metastable states can be particularly long lived in crystals, where they constitute the electron traps and the latent (photographic) images, which under certain circumstances may be frozen in and inactive at almost any temperature up to the melting point. Furthermore, systems of ions and electrons, subject to recombination, can also be considered as electronically metastable states.

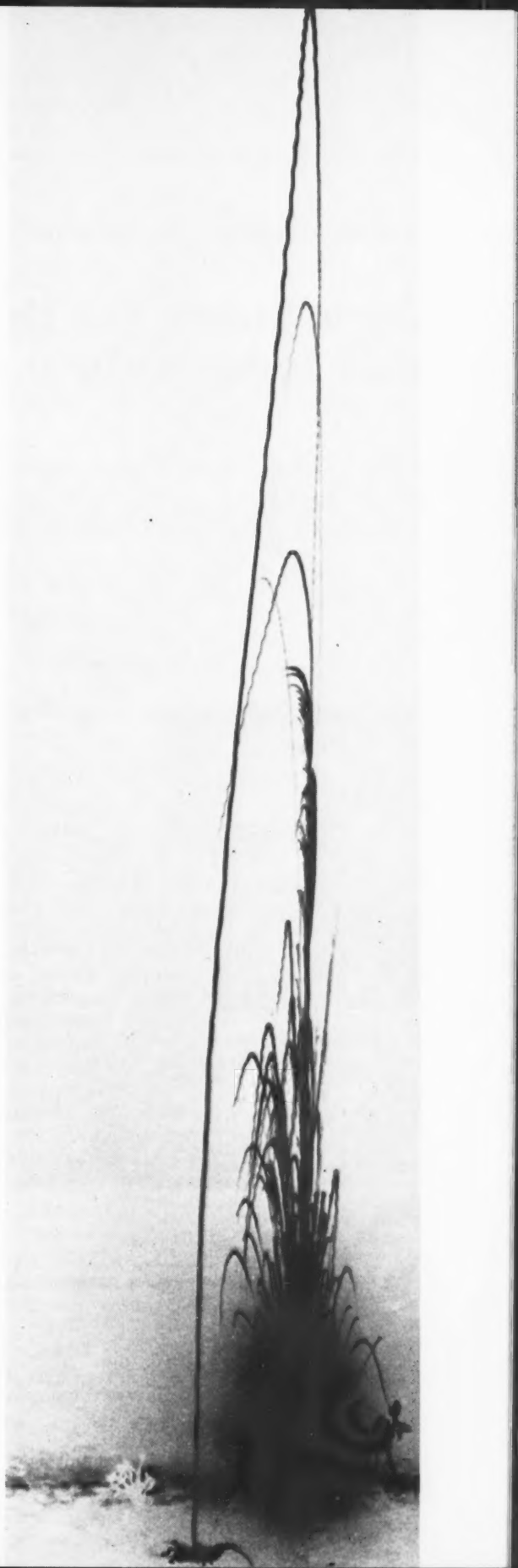
3. *Atomically metastable* states, from which quantum transitions produce radical rearrangements of the atoms in a molecule, or which may even cause its disintegration, as in C_2H_2. Isolated atomically metastable states will in general be long lived, a most attractive characteristic for their use as propellants. In this sense, the availability of helium hydride would be most desirable. If this molecule exists, it will be metastable, so that the dissociation of HeH into He + H liberates energy. The fact that the reaction products are both monoatomic and possess the highest possible gamma values guarantees the most efficient conversion of the liberated energy into propulsive energy.

Slowing Down the Reaction Rate

There are three obvious means to slow down the reaction rate between radicals or between metastable states. These are low temperature, traps and anticatalyzers. For instance, the reaction H + H into H_2 can only take place if the heat of reaction is emitted as quadrupole radiation. The respective transition probability is thus small, even if the emerging H_2 molecule is in a high state of oscillatory excitation. Multiple collisions greatly enhance the probability of reaction, and the use of either low temperatures, traps or anticatalyzers is indicated if one wishes to prevent multiple collisions or quench their effectiveness. If actual potential energy humps exist which must be overcome to initiate the reactions between radicals or metastable states, the use of low temperatures, traps or anticatalyzers will be particularly helpful in stabilizing the active particles in bulk density.

The most obvious methods of production and of stabilization of molecular fragments and of metastable states are as follows:

1. Dissociation and (CONTINUED ON PAGE 95)



Luminous tracks of ultrafast particles in this photo emanate from solid conical insert, consisting of easily oxidizable alloy, of shaped explosive charge.

ASTRONAUTICS Report—Part One

Engineering for the high temperature age of flight

In their quest for higher speeds, missile men have run into a thicket of heating problems. . . Here is a close look at those likely to beset various kinds of high speed flight vehicles, and ways of meeting them

By Frederick L. Bagby and Associates

BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

This report is itself an excellent example of the "new type of engineering technology"—the team approach alluded to by the authors.

Frederick L. Bagby, the principal author, is chief of the Aeronautics and Thermodynamics Div. at Battelle Memorial Institute. A graduate of the University of Utah, he had been associated with the Airplane Div. of Curtiss-Wright for four years before joining Battelle in 1946. At Battelle, he has conducted and supervised research in the fields of combustion, thermodynamics, fluid mechanics and aeronautical engineering.

Aiding Mr. Bagby in the preparation of this paper were Battelle-men W. A. Spraker and J. M. Allen, Aeronautics and Thermodynamics Div.; J. F. Quirk, Ceramics Div.; J. G. Dunleavy, Alloy Development Div.; and S. Palinchak, R. W. King and N. J. Broadway, Rubber and Plastics Div.

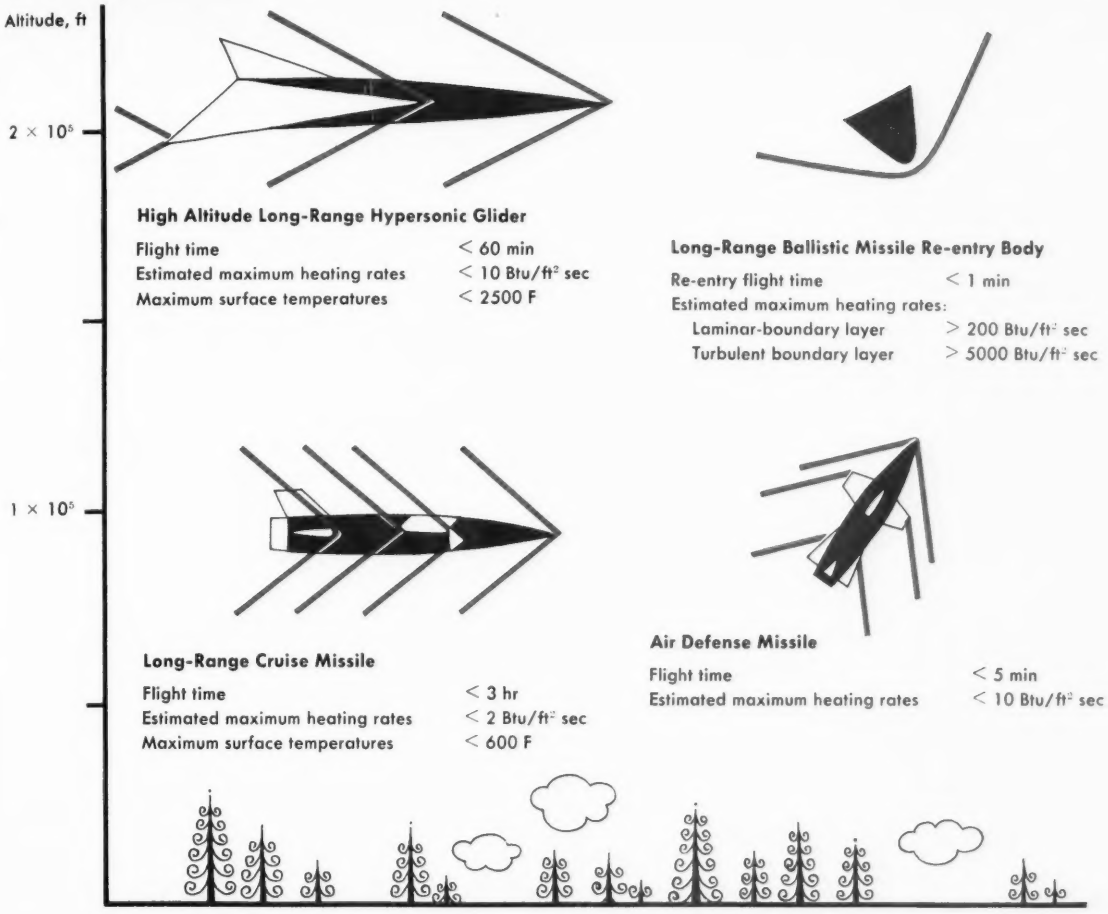
THE advent of practical jet propulsion devices has had far-reaching effects in the field of high speed flight. Military planners the world over have exploited the principle of jet propulsion to create new concepts and families of supersonic and hypersonic air weapons. With the approach of the launching of the first orbital satellite vehicles, scientists' dreams of conquering space no longer appear unreasonable.

To the aeronautical engineer, the effects of high speed flight have taken the more technical form of high temperature environments arising from aerodynamic heating and energy conversion processes. Many details about these new environments are unknown, and temperature extremes can be foreseen that are beyond the ordinarily understood capability of known engineering materials to withstand. A demand has thus been created for the development of a new technology, wherein old concepts of structural design and materials use must be replaced by new concepts not as yet completely formulated.

The fact that temperatures resulting from aerodynamic heating increase with increasing flight Mach numbers has led to general acceptance of the term "thermal thicket" as the proper description of the nature of the problem. A second, more careful look at the situation now indicates there are compensating factors which tend to make the aerodynamic heating aspect of the "thicket" less formidable than first assumed. These factors are the relatively short flight times involved in the operation of high speed vehicles; the reduced heating rates encountered in the upper, less dense portions of the atmosphere; and the fact that the radiation of absorbed heat back to the surrounding atmosphere may reduce the net heat input to a vehicle by substantial amounts. Similar compensating advantages do not accrue in the case of most other propulsion units.

Nor is the high temperature problem facing aircraft and missile engineers at this time strictly a matter of temperature alone,

Aerodynamic Heating



NOTE: **Component temperatures do not necessarily represent actual material temperatures, but rather possible maximum temperatures that components may be exposed to during certain flight conditions.**

since other aspects of the problem can under most circumstances be even more important. Take, for example, rates of heat transfer, total quantities of heat involved, and chemical reactions associated with high temperature. A thorough understanding of these facets of the problem is a prime requisite for the ultimate attainment of design objectives.

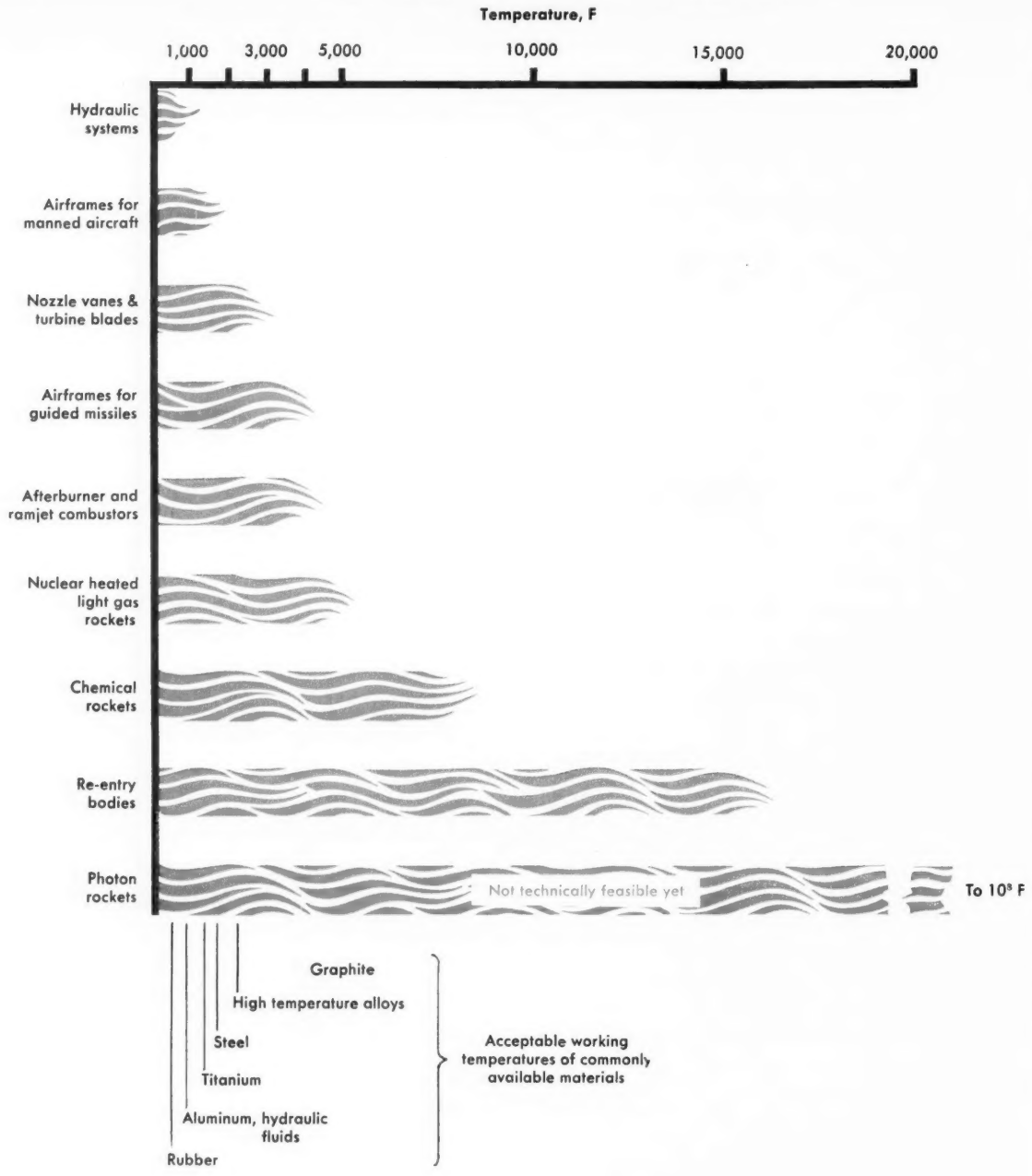
As may be seen in the chart on the following page, a "high temperature" problem can exist in temperature ranges as low as 200 to 400 F. In this region, hydraulic fluids and rubber seals now available present a definite limitation to designers.

High temperatures realized in airframes of manned aircraft flying in the stratosphere depend on a number of factors. Rocket-powered research aircraft have reportedly reached speeds above 1900 mph in the upper atmosphere. At these speeds, airframe parts of near-future aircraft might encounter temperatures of at least 1000 F as a result of aerodynamic heating.

Temperatures encountered by guided missile airframes, exclusive of re-entry bodies, will undoubtedly reach higher values than those for manned aircraft, at least in the near future. Unmanned aircraft or cruise type missiles generally present the same problems with regard to aerodynamic heating as manned aircraft. Guided missiles of the ordnance or aeroballistic types, such as surface-to-air and air-to-air missiles, can generally be expected to reach higher velocities than aircraft types. Reports of research rockets attaining velocities of 4500 mph indicate that temperatures of 3000 F and up may be encountered in the near future by the aeroballistic missile airframe.

The problem of "high temperature" is a long-standing one in the case of air-breathing propulsion systems. Turbine inlet temperatures of 1600 F and better represent the current level of accomplishment in gas turbine engines. Since such engines operate essentially at steady-state conditions for

Operational Temperatures—"High Temperature" Problems Start at 200 F



long periods of time, turbine inlet temperatures will usually also represent maximum material temperatures unless cooling techniques are employed. Turbine inlet temperatures greater than 2000 F can now be foreseen.

Combustors and tailpipes for gas turbines, afterburners and ramjets represent combustion system components exposed to flame temperatures. Fuels used in these propulsion units can burn with flame temperatures ranging up to 4000 F, and thus represent an upper temperature limit to which air-breathing engine components may be exposed.

Rocket engines are another example of the high temperature extremes the engineer must contend with. Chemical rockets, which convert the heat from combustion into kinetic energy of the products of combustion, can have flame temperatures ranging from about 4000 to 9000 F. The nuclear

rocket, using the fission process as the heat source, and light gases such as hydrogen or ammonia as the working fluid, will generate thrust in the same manner as the chemical rocket, but probably at temperatures in the order of 3000 to 5000 F.

Of current interest is the high temperature region associated with the re-entry of such bodies as nose cones of long-range ballistic missiles, satellite vehicles designed for re-entry and boost-glide vehicles. Depending upon the kinetic energy possessed by the re-entry body and the flight path, temperatures from 2000 to over 15,000 F may exist in a boundary or shock layer.

Finally, as an upper limit, there are the temperatures embodied in the photon rocket concept. This type of rocket, postulated thus far in theory only, involves temperatures associated with the conversion of matter to light energy. These may exceed 100,000,000 F, and represent physical conditions completely beyond the scope of current propulsion technology.

The examples of high (CONTINUED ON PAGE 98)

Propulsion Systems—Some Selected Characteristics

Type	Temperature ranges, F	Comments
CHEMICAL REACTION		
Ramjets and turbojets	2000–4000	Products of combustion of JP-4 and air are corrosive to combustor and tailpipe materials.
Solid propellant rockets	2500–5000	Typical propellant grain would be ammonium perchlorate and a fuel such as C_2H_4O. No cooling for nozzle and combustor so operating times are limited.
Standard liquid propellant rockets	4000–5700	Typical propellant combination is JP-4 and lox. Heat fluxes in throat of nozzle can exceed 3000 Btu/ft^2 sec. Chamber pressures up to 1000 psi and erosion from gas flow and combustion oscillations place extreme demands on materials.
High energy liquid propellant rockets	up to 8500	Use of high energy propellants such as H_2 and F_2 will result in more severe service conditions than for conventional propellants.
Free radical fueled rockets	3000–5000	Use of free radical fuels represents an attempt to increase specific impulse of chemical rocket up to the order of 1000.
HEAT TRANSFER		
Nuclear rocket	3000–5000	Nuclear fission is source of heat for accelerating light gases such as H_2 and NH_3. Will represent difficult materials problem.
Plasma jet	up to 20,000	High energy electric arc supplies energy to produce hot, ionized light gases which are discharged through conventional convergent-divergent nozzle.
Solar	up to 8000	Solar collectors gather radiant heat which is then transferred to a working fluid such as light gases.
ION ACCELERATION		
Electrostatic acceleration of ions	—	Ions such as those of sodium are accelerated by electric fields. Nuclear reactor required to provide electric power. System only applicable to space flight because of low thrust-to-weight ratios.
PHOTON		
Conversion of matter to light energy	temperature up to 10^8 F possible	Principle based on conversion of mass to energy according to Einstein relation, $E = mc^2$. No material known with high enough reflectivity to collimate light without the material melting from absorbed heat.

Toward improved missile communications

Bell Labs' ferromagnetic and "maser" microwave amplifiers may allow telemetering stations to receive weaker signals

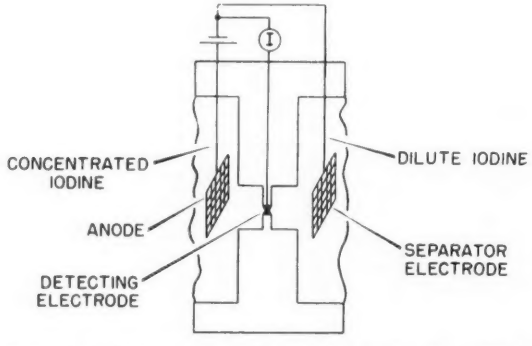
By Robert C. Toth

TWENTIETH century communications, from television to telemetering and from radar to radio astronomy, have been crowded into the high frequencies of the microwave regions beyond 1000 mc. Propagation characteristics of these super-abbreviated energy waves differ significantly from those of their longer brothers in the radio broadcast field, however, requiring scientists to go to sometimes bizarre electronic devices to cope with the problems.

Intensive studies in the area of ultra-sensitive amplifiers of microwaves have been going on, for example, since it was realized that present devices were limited to the lower frequencies. Perhaps the most concentrated work in this field being done is in the university-like atmosphere of Bell Telephone Laboratories at Murray Hill, N. J.

Effort has also been expended at the other end of the wave-length spectrum, in the region where the waves stretch out and frequencies slow to dc. Inertial navigation systems operate at such frequencies, and the Naval Ordnance Laboratory at Silver Spring, Md., recently announced an accelerometer-type device in this area.

In all these devices, the common control item is electron mobility. In electron tubes, electrons are moved in a vacuum or gas; in transistors, they move in solids. In Bell's solid state devices for "microwave amplification by stimulated emission of radiations," or "masers," the spin of the electrons is all important. Again, Bell's ferrite amplifier depends on electron properties in a solid. Finally, liquid mediums have made the grade. In NOL's "solion" devices, for example, the control of electrons moving in solution is utilized.



Separated detector cell of "solion" family devised by NOL and Defense Research Labs at the University of Texas, capable of use as an accelerometer of limited sensitivity.

Thermal Noise Limits Sensitivity

Vacuum tubes amplify by using a grid to make the outgoing and stronger signal conform to the incoming weaker signal. Thermal noise seeping from the hot electrode, however, severely limits the sensitivity of the receiver using the tubes. The vacuum tube has the additional drawbacks of being relatively complex and short lived, the latter due to the heat generated in driving off the electrons that pass through the grid.

Transistors, while overcoming these liabilities for the most part, are limited to the lower, i.e., below microwave, frequencies in their application, at least at present.

Now Bell, inventor of the transistor, believes it has two answers to microwave propagation with molecular amplification techniques, perhaps capable of increasing the sensitivity of receivers several hundred times. Chronologically, the first of the experimental devices is the three-level electron spin solid-state maser. A later device is based on the ferrite crystal, a fused compound consisting of paramagnetic salts of several metals. Garnet crystals can be used like ferrite but are less attractive.

Of the two microwave amplifiers, the ferromagnetic type appears most promising. Whichever proves best, however, a company spokesman was sure that it will not make the transistors obsolete, but rather will complement the tiny sandwich.

If the amplifiers work out as expected, radar stations will have a deeper sweep and radio astron-

omers will probe deeper into the galaxies with their sightless eyes. Further, telemetering stations will be able to pick up weaker signals from rockets or satellites transmitting on microwaves. (The IGY satellite, however, will use a frequency of 108 mc, far below the microwave region.)

In earth-bound communications, microwave stations on the DEW line could be placed farther apart. Enough of the straight line waves will scatter around the curvature of the earth to be picked up by such sensitive amplifiers.

Key to very sensitive amplifiers is to lower the internal noise level of the amplifier as much as possible. Noise abounds in a vacuum tube at high levels—flicker noise, induced grid noise, shot noise, partition noise. Molecular amplifiers are not plagued in this manner, boasting noise figures under one decibel for the maser. The ferrite device has a theoretically comparable noise figure. Bell scientists hope to measure the actual level soon.

A maser amplifies by working with the internal molecular energy states of electrons; in particular, with their spin energies. Previous microwave generators converted d-c power to microwave power by the interaction of moving charged particles, or electrons, with a microwave field. But molecules can also interact with a microwave field to convert internal energy into microwaves. Emission of visible light, of very high frequencies, in a fluorescent tube is a manifestation of internal molecular energy.

However, a profound difference exists between that process and microwave emissions. For the most part, light is radiated spontaneously, incoherently and independently of other radiations from adjacent molecules. Microwave radiations, on the other hand, can be induced by emissions from a neighboring molecule in a coherent manner; that is, the emissions are phase-related to the general radiation field.

Stimulates Microwave Emission

Specifically, the difference in spin energy levels of the electrons is proportional to a microwave frequency. When that frequency is imposed on the molecule, the energy is either absorbed, causing electrons in the lower state to hop to the higher one, or it stimulates emission of microwaves of identical frequency, in which case electrons in the upper state drop to the lower.

In the first maser, a beam of ammonia gas was separated physically into molecules whose electrons were at the higher state and molecules whose electrons were at the lower. Then, by piping a small signal at the resonant frequency into the more energetic group, most of the electrons were triggered to drop down, (CONTINUED ON PAGE 112)

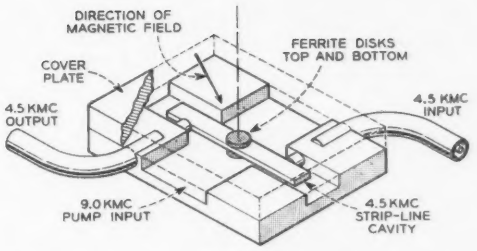
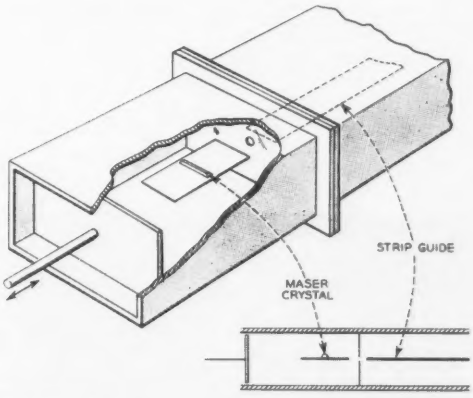
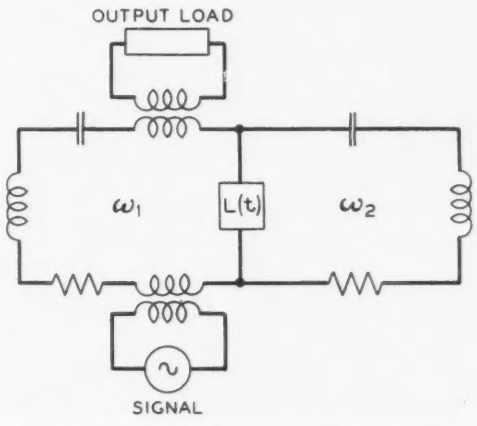


Diagram of the experimental ferrite microwave amplifier that was made to operate at Bell Labs last month.



Sketch of the resonant cavity and crystal for the three-level solid-state "maser" successfully operated at Bell Labs earlier this year.

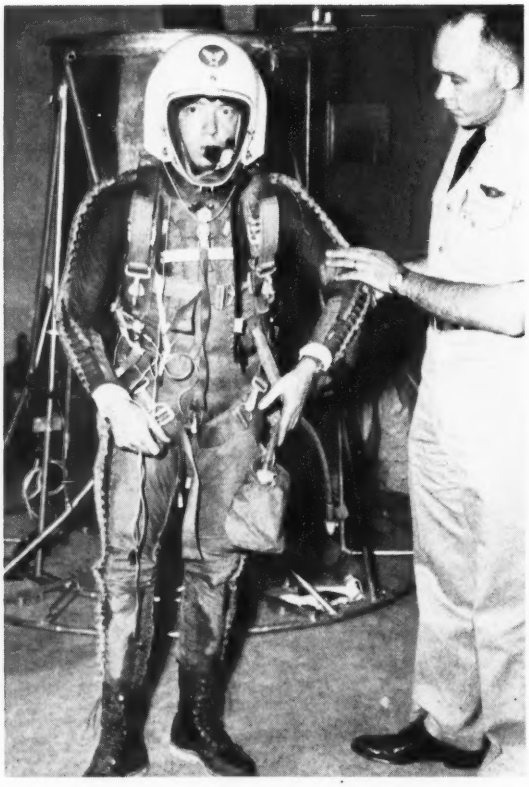


Circuit analog of the ferrite amplifier. ω_1 and ω_2 correspond to resonant frequencies of loops, with the coupling either an inductance or capacitor of common load L (t).

On top of the world

The complete story of Capt. Joe Kittinger's 96,000-ft balloon ascent, the first of a series of long-duration tests designed to determine man's ability to withstand extremely high altitudes

By Col. John P. Stapp
CHIEF, AERO MEDICAL FIELD LABORATORY
HOLLOMAN AFB, N. MEX.



STARTING TIME—11:30 p.m. June 1. Maj. David G. Simons, Chief, Man-High Project, inspects Capt. Joe Kittinger, Holloman AFB test pilot, clad in M-3 partial pressure suit and helmet, as he prepares to climb into the gondola.

AT 6:23 a.m. on June 2, 1957, at Fleming Field, South St. Paul, Minn., Capt. Joe Kittinger of the USAF's Air Research and Development Command was launched inside a 900-lb gondola lifted by a 2-million cu ft balloon made of polyethylene of 2 mil thickness, and ascended at an average of 1230 ft a minute to an altitude of 96,000 ft.

This was the initial test flight of what may be a series of long-duration tests at extreme altitudes.

Aside from determining the feasibility of using the manned balloon vehicle, Capt. Kittinger made several interesting observations. He observed that line-of-sight view from a point just over Minneapolis to the horizon included all of Lake Michigan, or a circle 800 miles in diameter, and that the horizon shaded very gradually to the dark blue of the heavens seen at altitude.

Valved Away Free Lift of Balloon

His descent was by valving away free lift of the balloon, and went according to plan. One mild thrill was occasioned during passage through the tropopause, when the balloon descended into a 93 mph jet stream. There the 25-story tall gas bag flattened like a sail and pitched the gondola about briefly. Descent rate increased from about 400 ft a minute to over 600 ft a minute in the lower, denser air. At about 4000 ft, the rate had increased to about 1000 ft a minute.

Capt. Kittinger then dropped off his remaining ballast—three aircraft 24-volt wet cell batteries on parachutes—but the momentum of descent was not

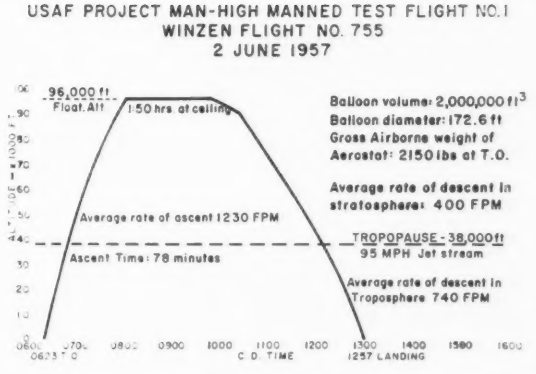
retarded before he hit the ground on the soft bank of a creek near Weaver, Minn. He promptly released the balloon, which sailed away to be recovered 24 hours later about 120 miles from the west shore of Lake Michigan.

Gondola Toppled into Creek

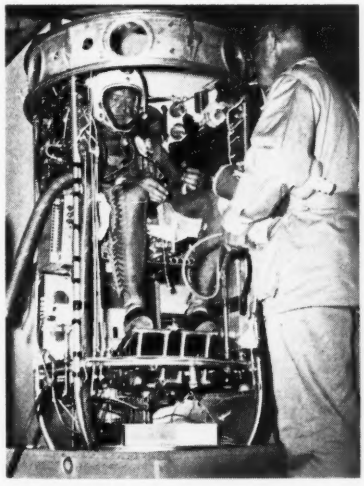
The gondola gently toppled off the bank and into the creek on its side, with the two open windows up. Two rescue helicopters from the 475th Air Base Squadron, Wold-Chamberlain Field, Minneapolis, landed nearby. All hands rushed to the creek, waded in, righted the capsule, and stepped back while Capt. Kittinger released the lid.

Like a man from Mars, he stepped out, radiantly happy, saying, as he removed his helmet, "This is the most wonderful day of my life."

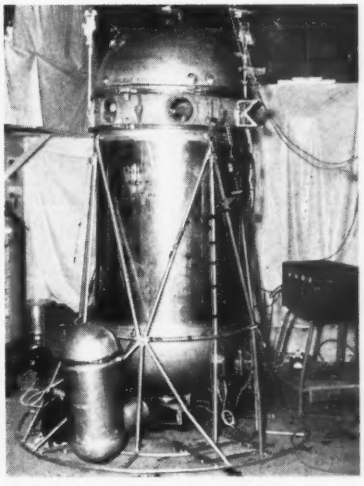
All of us agreed.


USAF PROJECT MAN-HIGH MANNED TEST FLIGHT NO. I
WINZEN FLIGHT NO. 755
2 JUNE 1957
96,000 ft
Float Alt
1:50 hrs. at ceiling
Balloon volume: 2,000,000 ft³
Balloon diameter: 172.6 ft
Gross Airborne weight of Aerostat: 2150 lbs at T.O.
Average rate of descent in stratosphere: 400 FPM
Average rate of ascent 1230 FPM
TROPOPAUSE - 38,000 ft
95 MPH Jet stream
Ascent Time: 78 minutes
Average rate of descent in Troposphere 740 FPM
ALTITUDE (1000 FT.)
0623 T.O.
C. D. TIME
1257 LANDING

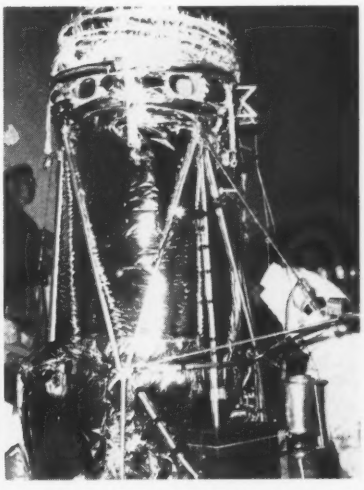
Flight pattern for the Kittinger flight, first in a series of manned balloon tests carried out by the Air Force in Project Man-High.



0 MINUS 6 HOURS—12 midnight. Capt. Erwin R. Archibald, aviation physiologist, installs specimen bottles in the gondola. Capt. Kittinger, crowded by instruments, is ensconced on a nylon netting seat installed in a cylindrical area 3 ft in diam and 7 ft high.

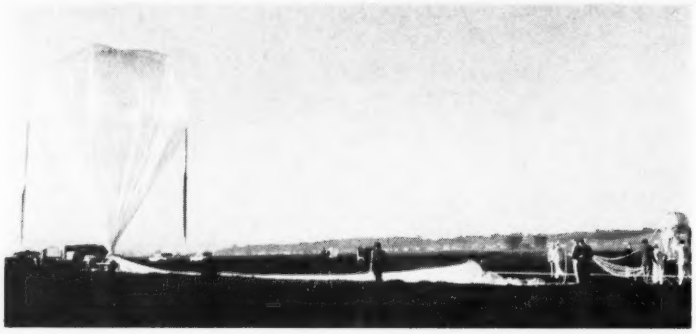


SWEATING OUT NITROGEN—1 a.m. June 2. Capt. Kittinger, in closed gondola, is fed a mixture of helium and oxygen so he can eliminate all excess nitrogen from his tissues. High altitude bends could result from rapid decompression if nitrogen entered blood-stream.



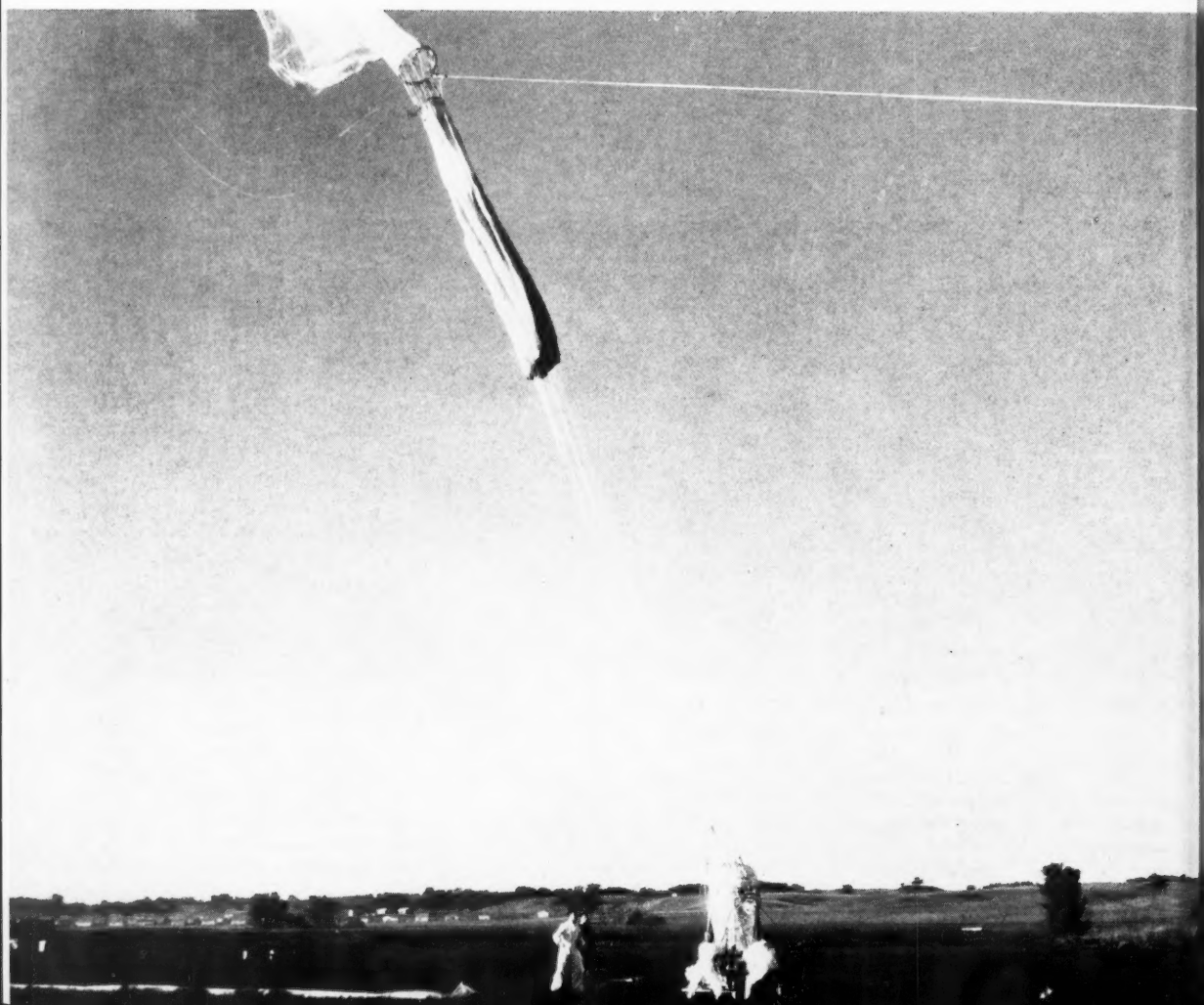
READY FOR LAUNCHING—5:30. Gondola sits at Fleming Field like a giant thermos bottle as last-minute preparations are made. Gondola is swathed in four layers of aluminum-coated mylar interwoven with honeycomb paper and capped by 50 lb of dry ice to keep it cool.

INFLATING THE BALLOON—5:35. Inflation of the 2-million cu ft Winzen balloon, made of 2 mil polyethylene, gets under way as dawn comes up over the field.



READY TO GO—6 a.m. Fully inflated, lift of the balloon is now 2000 lb gross, the net being 10 per cent above gondola weight to permit 1000-ft-a-minute rate of ascent.

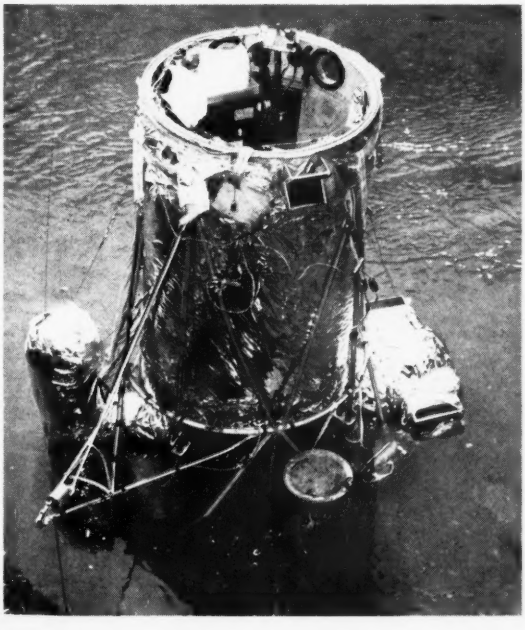
ON ITS WAY—6:23:30. Risers on the big parachute snap tight and the gondola smoothly lifts into the air for the beginning of its ascent to unofficial record of 96,000 ft.



UP SHE GOES—6:28. At ascent rate of 1230 ft a minute, gondola begins steady rise that will go on for 78 minutes. Capt. Kittinger transmits: "No sweat on take-off. Farewell, cruel world."

ASCENT CONTINUES—6:33. Towering 25 stories over parachute and gondola, helium-filled gas bag grows fatter as atmospheric pressure drops. Dark spot in top is venting valve operated from gondola.

DOWN AND OUT—1:30 p.m. Gondola landed on bank of a creek and, when balloon was released, toppled into water, where it lay on its side until righted by rescuers. Capt. Kittinger climbed out feeling fine after first manned balloon ascent to more than 76,000 ft and nearly 19 hr in pressure suit.



MOST HAPPY FELLAS—Left to right are Otto Winzen, president of Winzen Research, Inc., maker of the balloon, gondola and other equipment for the flight; Capt. Kittinger; and Maj. Simons, of Holloman AFB, who planned, organized and managed the entire program.

Who's who in the IGY

These are the men responsible for coordinating the U.S. research rocket and earth satellite efforts—and this is what they will be trying to achieve in programs planned for the next 18 months

The research rocket program

USNC-IGY Technical Panel on Rocketry

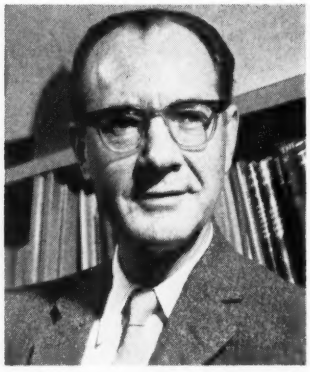
Panel Members:
Fred L. Whipple, chairman
Homer E. Newell Jr., executive vice-chairman
W. W. Berning
William G. Dow
N. C. Gerson
Bernard Haurwitz
Joseph Kaplan
W. J. O'Sullivan
S. F. Singer
William Stroud
John W. Townsend Jr.
James A. Van Allen
Peter H. Wyckoff
N. W. Spencer (alternate)

Consultants:
L. M. Jones
Hilde M. Kallman
R. M. Slavin
K. E. Anderson

Department of Defense Task Group Representatives:
P. H. Watras (Army)
L. G. Smith (Army)
William Stroud (Army)
H. E. Newell Jr. (Navy) or
J. W. Townsend Jr. (alternate)
O. E. Hearn (Navy)
E. E. Duff (Air Force)

Inter-Service Coordination Group:
L. G. Smith
E. E. Duff
O. E. Hearn
P. H. Watras

Special Committee (Working Group):
H. E. Newell Jr., chairman
J. W. Townsend Jr., secretary
W. W. Berning
L. M. Jones
K. H. Anderson
R. M. Slavin
N. W. Spencer
W. G. Stroud



Fred L. Whipple
Chairman

Homer E. Newell Jr.
Executive Vice-Chairman

Panel Function

Bears fundamental responsibility for the U.S. IGY research rocket program, designed to provide basic data for upper atmosphere research which cannot be accumulated through ground-based experiments.

Launching Sites and Firings

Fort Churchill, Canada—34 Aerobees, 42 Nike-Cajuns
Holloman AFB—7 Aerobees
White Sands Proving Ground—5 Aerobees, 2 Nike-Cajuns
Point Mugu, Calif.—14 Nike-Deacons
Shipboard Launchings—90 Rockoons

Experiments Planned

Meteorology: Measurement of upper atmosphere temperatures, pressures and densities; studies of solar x-ray penetration into the atmosphere; determination of upper atmosphere winds; location of optical horizon; determination of distribution of ozone in the upper atmosphere.

Solar Activity: Measurement of solar radiations in various wave lengths; studies of the solar spectrum.

Airglow: Measurement of airglow in various wave length regions of the visible spectrum; nightglow studies centering on measurement of OH bands in the near infrared regions.

Aurora: Measurement of auroral particles; determination of ultraviolet fluorescence of upper atmosphere during auroras.

Ionospheric Physics: Determination of ionospheric charge densities; measurement of chemical and ion composition of the upper atmosphere, measurement of atmospheric winds.

Geomagnetism: Measurement of the earth's magnetic field, with such measurements used to locate ionospheric and auroral current flows.

Cosmic Rays: Measurement of low-energy cosmic rays as a function of geomagnetic latitude and correlation of their fluctuations in intensity with solar and magnetic phenomena.

The earth satellite program

Richard W. Porter
Chairman

Joseph Kaplan
Chairman, USNC-IGY
Member Ex-Officio

Panel Function

Bears responsibility for the over-all development, coordination and direction of the satellite program, with the vehicle and its design, construction and launching the responsibilities of the Naval Research Laboratory.

The Satellite Vehicle

The satellite will be placed in orbit by a 72-ft-long, three-stage rocket. The rocket will be finless, using internal controls for guidance. A complete description of the satellite vehicle will be found on page 62.

The Satellite

The first satellite will be spherical, about 20 in. in diam. It will weigh approximately 21.5 lb. About half of this will be structural weight; the other half will be left for the various instruments, including the telemetering system.

Launching

Present plans call for launching next year at Cape Canaveral, Fla. The vehicle will be launched in an easterly direction to take advantage of the earth's rotation to gain added velocity.

Orbit

The satellite's orbit will permit it to revolve about the earth in an apparent latitude range of about 35 deg on either side of the equator. It will in all probability be set on an elliptical orbit some 200–300 to 800–1500 miles above the earth.

Ground-Based Experiments

An important set of experiments relates to observation, measurements and calculations which can be made from ground stations. Among these are experiments to determine the density of the upper atmosphere; to determine the composition of the earth's crust and the earth's oblateness; and to determine some of the electric charge characteristics of the ionosphere.

Satellite-Borne Experiments

Experiments depending upon instruments carried in the satellite itself (see page 66) will include measurement of ultraviolet radiation from the sun and of the earth's magnetic field; determination of the total incidence of cosmic rays; and measurement of terrestrial energy balance. An alternate for the latter is an experiment to determine the cloud cover of the earth.

In addition, several environmental experiments are planned. These will indicate leakage rate in the satellite in case of meteorite puncture; measure surface erosion due to micrometeorites and gas molecules; record the number of encounters with micrometeorites; and measure skin and internal temperatures of the satellite.

USNC-IGY Technical Panel on the Earth Satellite Program

Panel Members:
Richard W. Porter, chairman
Joseph Kaplan, member ex-officio
J. G. Reid Jr., secretary
G. M. Clemence
Michael Ference Jr.
Hugh Odishaw
Homer E. Newell Jr.
W. H. Pickering
Athelstan F. Spilhaus
James A. Van Allen
Fred L. Whipple

Consultants:
John P. Hagen
J. Wallace Joyce
T. J. Killian
Joseph C. Myers
Paul A. Smith
Charles S. Weaver

Department of Defense Counterpart Members:
J. B. Edson
George Grimminger
J. P. Hagen
Lt. Col. G. P. Jones
T. J. Killian
Harold Zahl or
Hans K. Ziegler (alternate)

Working Group on Internal Instrumentation:
J. A. Van Allen, chairman
LeRoy R. Alldredge
Michael Ference Jr.
Herbert Friedman
William W. Kellogg
R. W. Porter
Lyman Spitzer Jr.

Working Group on Tracking and Computation:
W. H. Pickering, chairman
G. M. Clemence
W. A. Heiskanen
G. P. Kuiper
J. P. Mengel
J. A. O'Keefe
F. L. Whipple

Air Force Liaison:
Lt. Col. Clyde H. Barnett or
William L. Berry (alternate)

Rundown on the Vanguard vehicle

An up-to-date report on the 10-minute trip through space of three-stage rocket that will place the earth satellite in orbit

THE most dramatic United States experiment in search of scientific knowledge to be carried out during this International Geophysical Year will undoubtedly be attempts to launch six earth satellites —21½ lb globes, 20 in. in diam and packed with instruments to measure high altitude phenomena.

To get the spheres 300 miles, or 261 nautical miles, up and moving parallel to the earth's local horizon at a minimum of 25,034 fps, will require a three-stage vehicle weighing 22,600 lb at take-off, or about 1000 lb for each pound of satellite, according to Naval Research Laboratory scientists responsible for the feat. The first attempt is not expected before 1958.

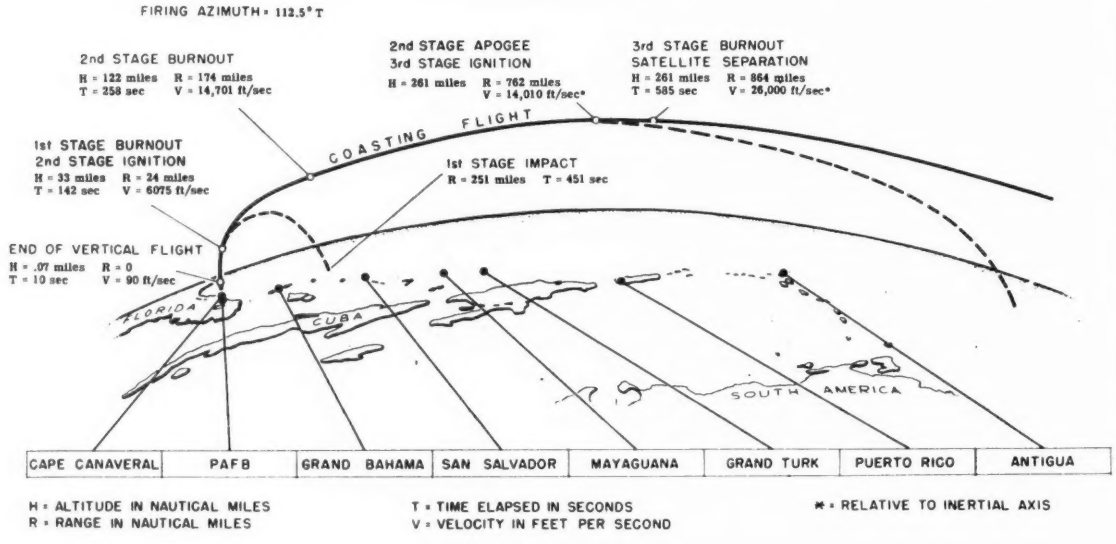
NRL's John P. Hagen, director of Project Vanguard, recently presented to the U. S. National Committee of the IGY the most comprehensive report to date on the vehicle. The committee met in Washington on the eve of the international scientific year, which began July 1.

Two test vehicles have already been fired with equipment and instruments that will be carried in the first full-scale vehicle. Five more test vehicles are planned to check out every possible item before the first attempt is made to place a satellite in orbit.

That first full-scale attempt, Dr. Hagen noted, will consist of two finless cylinders mounted atop each other, the first 44 ft high and 45 in. in diam, the second 31 ft high and 32 in. in diam. With a nose cone to protect the third stage and satellite that sit within Stage II, the vehicle will measure 72 ft high as it sits above the sands at Cape Canaveral in Florida before firing. From this site, latitude 28°30′ north, the satellite will be launched south of east 35°, accruing a bonus velocity in orbit of 1300 fps, or 3 per cent of its total speed, from the earth's rotation about its axis.

The vehicle will rise on its tongue of flame vertically for 10 sec, its gimballed motor developing full 27,000-lb thrust. Program controls in the second stage will bend the vehicle into a trajectory calculated to take it to optimum satellite launching position. When first-stage kerosene and liquid oxygen give out, the vehicle will be rushing out of the

TRAJECTORY DATA AND ELECTRONIC GROUND STATION LOCATIONS


FIRING AZIMUTH = 112.5° T
2nd STAGE BURNOUT
H = 122 miles R = 174 miles
T = 258 sec V = 14,701 ft/sec
2nd STAGE APOGEE
3rd STAGE IGNITION
H = 261 miles R = 762 miles
V = 14,010 ft/sec*
3rd STAGE BURNOUT
SATELLITE SEPARATION
H = 261 miles R = 864 miles
T = 585 sec V = 26,000 ft/sec*
COASTING FLIGHT
1st STAGE BURNOUT
2nd STAGE IGNITION
H = 33 miles R = 24 miles
T = 142 sec V = 6075 ft/sec
1st STAGE IMPACT
R = 251 miles T = 451 sec
END OF VERTICAL FLIGHT
H = .07 miles R = 0
T = 10 sec V = 90 ft/sec
FLORIDA
CUBA
SOUTH AMERICA
CAPE CANAVERAL
PAFB
GRAND BAHAMA
SAN SALVADOR
MAYAGUANA
GRAND TURK
PUERTO RICO
ANTIGUA

H = ALTITUDE IN NAUTICAL MILES
R = RANGE IN NAUTICAL MILES
T = TIME ELAPSED IN SECONDS
V = VELOCITY IN FEET PER SECOND
* = RELATIVE TO INERTIAL AXIS

atmosphere at 3700 mph, this stage having contributed 65 per cent of the total energy necessary to raise the second stage to orbital altitude and about 15 per cent of the required orbital velocity of the satellite. Six explosive bolts will break the burned-out stage from the still live vehicle, sending it spinning down to splash into the South Atlantic 288 miles from Cape Canaveral.

Stage II will begin very soon after Stage I breakaway. Pumps will send unsymmetrical dimethyl hydrazine and white fuming nitric acid coursing to the motor's combustion chamber, where the hypergolic mixture will spontaneously ignite. Thrust from the gimballed motor will drive the 4800 lb of the remaining vehicle to 9700 mph before burnout at 140 miles above the sea. Shortly before burnout, however, the nose cone will fall free, exposing the satellite and third stage to the tenuous atmosphere.

The entire vehicle will be controlled from the second stage. Pitch and yaw can be compensated for by means of the gimballed motors through electrohydraulic systems. In the second stage, gas jets will provide roll control during powered flight and complete control during coasting flight after burnout for proper orientation for third-stage launching.

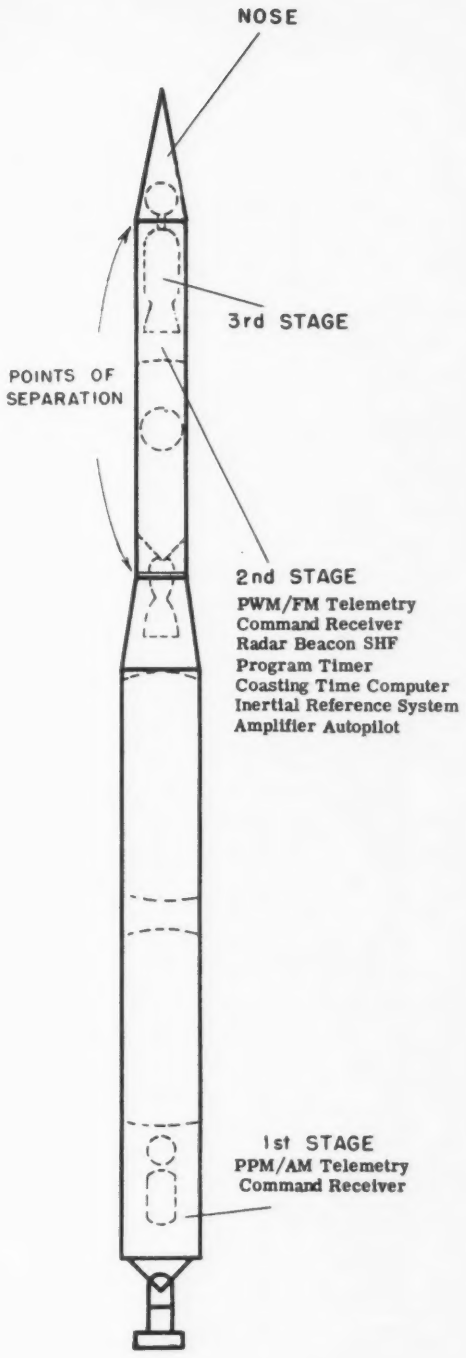
In addition to attitude controls, Dr. Hagen told the USNC-IGY, there will be included among second-stage control elements a programmer which would introduce rate changes "to secure the optimum trajectory and rocket-staging events," and a coasting-time computer which would, on the basis of integrated acceleration, "establish the optimum time for ignition of the third-stage rocket."

After Stage II burnout, the vehicle will coast up to 300 miles, the satellite orbital altitude. A rocket-powered turntable then will spin the third-stage rocket and the attached satellite sphere while they are still inside the second-stage cylinder. At the same time, retarding rockets will slow the second stage to allow the third stage, with the satellite, to ease out at roughly 9000 mph, or half the satellite's orbital velocity.

Then, its Vanguard "brain" useless, its fuel expended and its "children" ushered into space, the empty cylinder that was Stage II will point downward to the spot where it (CONTINUED ON PAGE 102)

Vanguard Weight and Performance Data

Gross wt, lb		22,600	
	First Stage	Second Stage	Third Stage
Thrust, lb	27,000	7,500	2,350
Burning time, sec	146	120	30
Velocity increment horizontal, fps	4,023	8,389	13,405



VEHICLE CONFIGURATION AND INSTRUMENTATION

IGY sounds off

One successful shot, one 'failure' mark first U.S. rocket firings at Fort Churchill, Canada

By Michael L. Yaffee

U. S. Army photograph

SUCCESS: First Fort Churchill IGY rocket heads for 155 mile altitude in what is considered a beautiful shoot.

Fort Churchill, Canada—The first IGY rocket fired here left the ground at 12:15:40.5 p.m., July 4. (Pre-IGY rockets were fired from Fort Churchill last fall; see JET PROPULSION, Jan. 1957, p. 52.) Rocket NN3.08F, a Navy Aerobee-Hi purchased by the National Science Foundation, climbed approximately 155 miles into the sub-arctic ionosphere, landed some 480 sec later about 91 miles from the launch site.

Although John E. Jackson, Naval Research Laboratory physicist in direct charge of the experiment, might have preferred a more vertical trajectory, this was considered an excellent firing.

In its unpressurized nose cone, the rocket carried, in addition to approximately 75 lb of conventional control, safety and tracking equipment, another 75 lb of specialized ionosphere instrumentation. This consisted principally of two c.w. transmitters, silver-zinc batteries, telemetering commutator, antenna matching box and an antenna erecting mechanism. Outside, hinged near the base of the nose cone, two 14-ft ionosphere whip antennas lay back against the rocket body, reaching almost to the tail section.

Transmitted Signals on Two Frequencies

Approximately 5 sec after burnout, at X+58 sec, the antennas pushed out 90 deg from opposite sides of the rocket, and the two transmitters went into operation, sending radio signals to a ground station some 1300 ft north of the blockhouse. One signal, transmitted at a frequency of 46.5 mc, was essentially unaffected by the ionosphere and served as a reference. The other signal, transmitted at 7.75 mc, was measurably modified by ionospheric conditions such as electron density, earth magnetic field intensity and electron collision frequency. The signals were recorded at the ground station, with the records slated to be gone over carefully and analyzed during the forthcoming months.

After a series of short holds, Jackson's second ionosphere rocket, NN3.09F, another RV-N-13c Aerobee-Hi, which was originally scheduled for midnight of the 4th, finally got off the ground at 00:17:55.5 a.m., July 5. This time, Jackson almost got his wish for a vertical shoot.

The rocket started out beautifully. But 20.5 sec later it was cut

U. S. Army photograph

FAILURE: After an excellent start, premature cut-off spoils second rocket's efforts to reach the ionosphere.

down through faulty operation of the radio-command range safety device in the rocket, which closed squib-actuated shut-off valves installed in the propellant feed lines. From the loudspeakers came word for everyone outside to return at once to the blockhouse! Then it landed—only $2^1/_4$ miles from the launch tower-blockhouse—and exploded, spilling unspent nitric acid and aniline over the area.

Although the rocket remained airborne for about $2^1/_2$ min, it reached a peak altitude of only 10 miles—30 miles short of the start of the ionosphere. Consequently, the shoot was considered a failure in the light of its intended purpose of probing ionospheric structure. On the other hand, it did give Jackson another chance to check his equipment and also to check a relatively new radio interferometer technique similar to the Minitrack system slated for use in tracking the Vanguard satellite vehicle.

The failure of the second firing, in fact, proved almost as valuable in its own way for rocket researchers in general as the success of the first firing is expected to prove for Jackson in particular. In addition to underscoring the unreliability of the rather vital range safety cut-off system, the second shoot showed up a weakness in the mercury cell battery used as a power source for the calibration data system. This battery was also scheduled for use in Vanguard.

At the post-shoot conference some 30 hours after the second firing, those directly involved in the first two firings reported on their particular operations. The collective attitude was essentially one of satisfaction and optimism. Mr. Jackson was particularly impressed and appreciative of the well-oiled cooperation of the various military personnel and civilian scientists, both (CONTINUED ON PAGE 113)

Ionospheric Jig-Saw

The ionosphere is that portion of the atmosphere from roughly 40 miles to perhaps 400 miles above the earth. It is in this region that reflection of radio waves occurs—or, sometimes, doesn't occur. It is this reflection from the free electrical charges that exist in the ionosphere that makes possible long-distance radio communications. When radio waves, instead of being reflected, pass on through the upper reaches of the ionosphere or are dissipated in the lower ionosphere, communication then becomes erratic or disappears altogether.

The ionosphere also holds other interest for scientists. It is a natural high-vacuum laboratory where ionization processes such as airglow and auroral displays occur and can be studied.

For these reasons, upper air scientists were quick to seize upon the post-World War II availability of high altitude rockets. These relatively new research tools now enable them to get a much closer look at the region and, perhaps more significant, to correlate "first hand" information with data obtained from ground recordings.

Although it would be desirable to obtain continual rocket readings of ionospheric structure above all parts of the earth's surface, this is a practical impossibility. (Even discounting the unavailability of enough safe launching areas, there is the cost of firing, which for a single sounding rocket may run as high as $100,000.) Consequently, the upper air scientists will try to shoot from a number of "typical" sites under as many different "typical" conditions—e.g., morning, noon, night, winter, summer, etc. —as possible. From this, they hope to be able to generalize about the ionosphere at all latitudes.

So far, U. S. scientists have sounded the ionosphere above White Sands, N. Mex., and Fort Churchill, Canada. These two areas, they hope, will serve as models for the temperate and arctic regions. Next will come firings from the tropics. With enough such scientific pieces of information, they hope eventually to complete the jig-saw puzzle of this important but relatively unknown region loosely defined as the ionosphere.

The Vanguard instrument package

Here's how 10 lb of tiny but reliable instruments will permit IGY scientists to perform major experiments in the fields of solar radiation, cosmic rays, geomagnetism and meteorology in the next 18 months

By Herbert Friedman

U. S. NAVAL RESEARCH LABORATORY, WASHINGTON, D. C.

Herbert Friedman has been on the staff of the Naval Research Laboratory for more than 15 years. In 1942 he became head of the Electron Optics Branch and since 1949 he has been engaged in upper air rocket research, particularly in the field of solar-terrestrial relationships. A member of the Working Group on Internal Instrumentation of the IGY Technical Panel on the Earth Satellite Program, he is currently involved in instrumentation of the first satellite.

OF THE more than 30 scientific experiments proposed for the IGY satellites, only five have been approved to date. These are in the fields of solar radiation, cosmic rays, geomagnetism and meteorology.

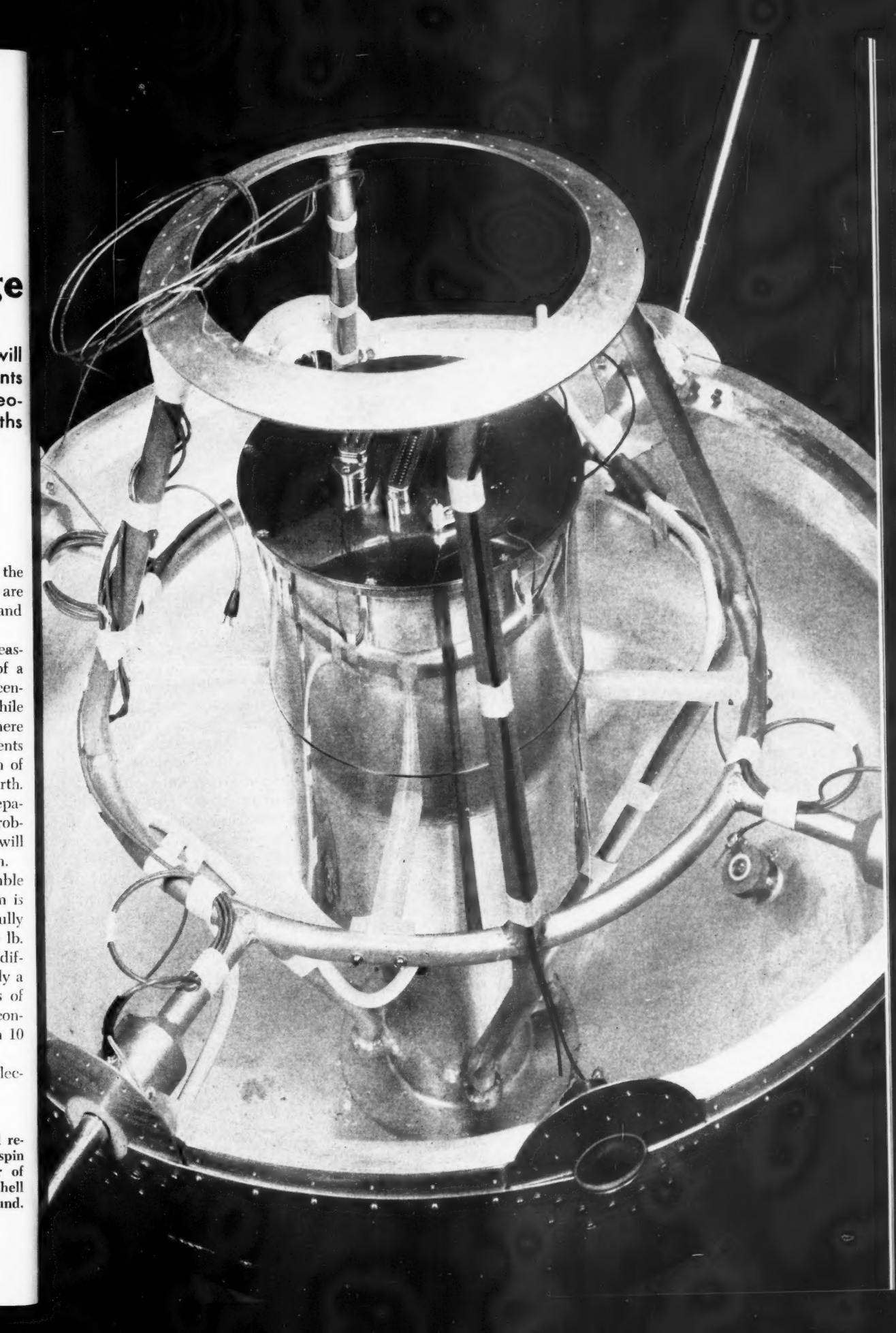
Instruments for the solar radiation experiment will permit measurement of Lyman Alpha radiation, as well as measurement of a group of environmental factors. Cosmic ray experiments will center on counting such rays over certain segments of the orbit, while measurements of the earth's magnetic field over the ionosphere will be made in the geomagnetic experiment. The two experiments planned in the field of meteorology deal with the determination of radiation balance and the distribution of cloud cover over the earth.

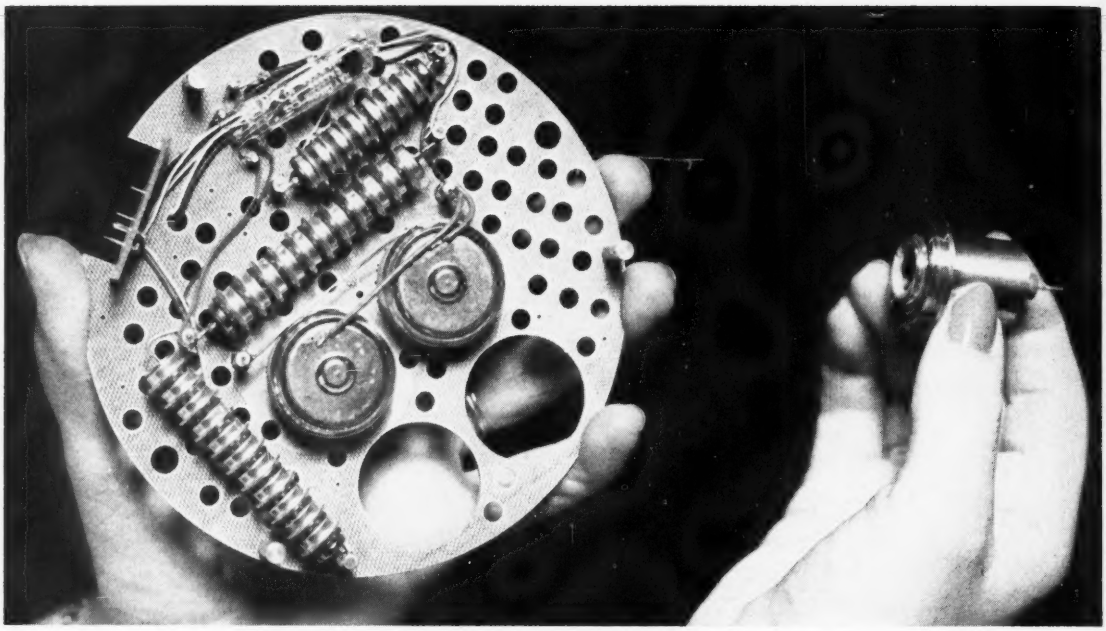
Since the radiation experiment is in an advanced state of preparation at the Naval Research Laboratory, a description of the problems involved in the design of instruments for this experiment will help illustrate the over-all approach to satellite instrumentation.

Although experiments scheduled to fly in IGY satellites resemble those that have been flown in rockets, a much greater premium is placed on miniaturization, power efficiency and reliability. Fully instrumented, the satellite shell must not weigh more than 21.5 lb. Adding only a couple of pounds to the payload may spell the difference between the satellite surviving aloft for a year or for only a few weeks, since each pound of payload costs about 33 miles of altitude. Of the total satellite weight, approximately half is contained in the shell and structural supports, leaving no more than 10 or 11 lb for all the instrumentation, including Minitrack.

To conserve weight, it is almost mandatory that transistor elec-

Interior of partially assembled satellite with upper half shell removed. Cylinder containing circuit packages is mounted on spin axis. Four antenna rods project radially through equator of sphere. Lyman Alpha ion chamber is shown mounted on shell with window exposed through surface in lower foreground.





Tube at right is ionization chamber for measurement of Lyman Alpha radiation. Card contains electrometer tube, resistor and batteries comprising circuit for measuring ionization chamber current.

tronics be used wherever possible. For example, a transistorized telemetering modulator weighs about one-tenth as much as a comparable vacuum tube circuit. But along with the weight-saving advantages of transistors, one must accept a maximum temperature limitation of about 80 C. A low temperature boundary is determined by battery performance. If mercury cells are used, battery life falls off rapidly below 0 C.

Will Permit Environmental Measurements

Complete instrumentation for the solar radiation experiment will permit measurement of the peak value of solar Lyman Alpha radiation during each orbit, as well as a group of environmental measurements from which basic engineering data will be gained for future satellites. Environmental instrumentation will include thermistors to measure temperature, evaporated resistance strips sensitive to erosion by meteors, impact microphones to count meteorites, and pressure gages to detect punctures of hermetically sealed zones.

The hydrogen Lyman Alpha line at 1215.7A is the brightest emission feature of the ultraviolet solar spectrum. It produces the ionization of the normal D-region and is believed to play an important role in sudden ionospheric disturbances that accompany solar flares. The ideal Lyman Alpha experiment would monitor this wave length continuously, but transmission of information from the satellite is limited to line of sight, and telemetering receivers will be located primarily along one meridian. The peak value of Lyman Alpha during each orbit will therefore be stored and read out as the satellite passes over the Minitrack "fence." At that time, instantaneous values of Lyman Alpha and aspect data from a solar cell will also be transmitted.

The elements that make up the Lyman Alpha experiment alone are a duplicate pair of specially designed ion chambers sensitive almost exclusively to this wave length, their associated electrometer circuit, a solar battery used as an aspect photocell, two magnetic memory circuits to store peak values of Lyman Alpha, and an orbital switch and resetting circuit. All these elements and their battery power supply add up to only 1.4 lb.

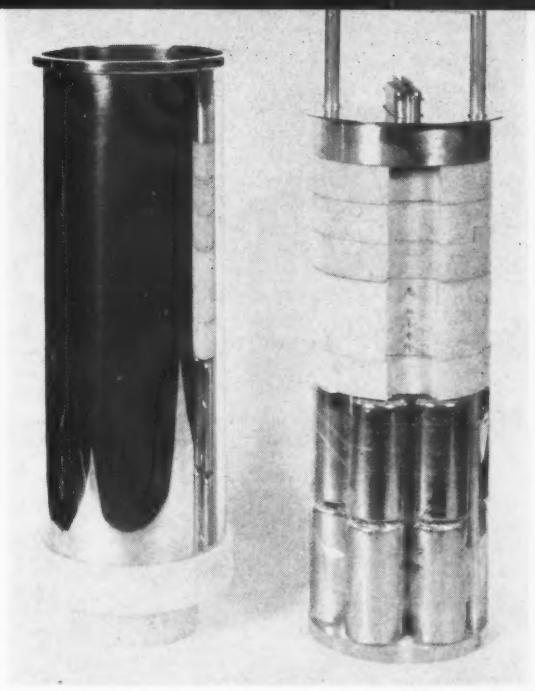
The ion chambers are mounted so that their fields of view provide an almost flat response independent of aspect at launching, when their current outputs are paralleled. The ion current, after amplification by the electrometer circuit, controls the flux level in a magnetic core. This core is the frequency controlling element of an audio oscillator that modulates the Minitrack transmitter. Two memory cores are used, so that one is storing data while the other is modulating Minitrack with the peak signal stored in the preceding orbit. The orbital switching of these cores is accomplished by a signal from the solar cell each time the satellite emerges from dark to light.

The memory core technique offers the advantages of nondestructive continuous "read-out" and great weight-saving over conventional capacitor storage circuits. As used in the Lyman Alpha experiment, the flux level in a toroidal core is set by the amplified ion chamber current that flows in its winding. The highest flux level is retained irrespective of any subsequent smaller currents in the winding. For read-out, the stored flux is divided into two paths by a small hole in the core, through which two read-out windings are inserted. A transistorized multivibrator switches the flux from one path to the other at a frequency determined by the flux level. This frequency is telemetered as the peak Lyman Alpha signal. Erasing the flux and switching from "read-out" to storage is accomplished with transistor switching circuits. The peak reader and orbital switch weigh 2.5 oz and require 1.4 oz of battery.

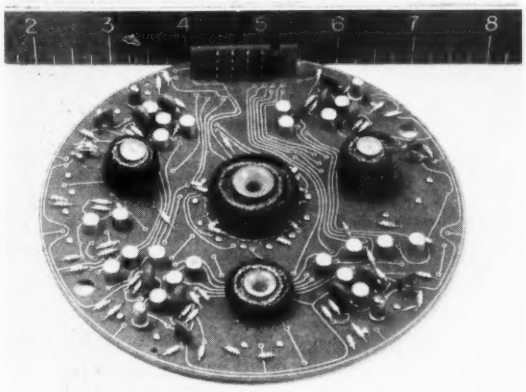
Applied to Count of Meteor Impacts

A magnetic core is also applied to the counting of meteor impacts. The magnetic counter is fed by transistor amplified signals obtained from barium titanate microphones. It stores and reads out continuously three decimal digits of accumulated counts. The entire unit weighs 3.1 oz and requires 1.4 oz of battery.

The telemetering encoder must accept a variety of signals from memory cores, instantaneous ion chamber currents, the silicon solar cell, erosion resistor strips, thermistors and pressure transducers. The telemetered data is presented as a series of high frequency bursts carrying information in the frequencies of the bursts, the duration of each burst and the time intervals between bursts. The high frequency bursts will span the range of 5 to 15 kc, while the duration and spacing of bursts will cover intervals of 5 to 30 millisec duration.



Electronic instrumentation package. Lower section contains batteries for Minitrack transmitter. Modules of circuits encapsulated in foam are stacked one above the other. Cylinder is $5^1/_2$ in. in diam and $7^1/_2$ in. high.



Transistorized printed circuit layout of 48-channel telemetering encoder.

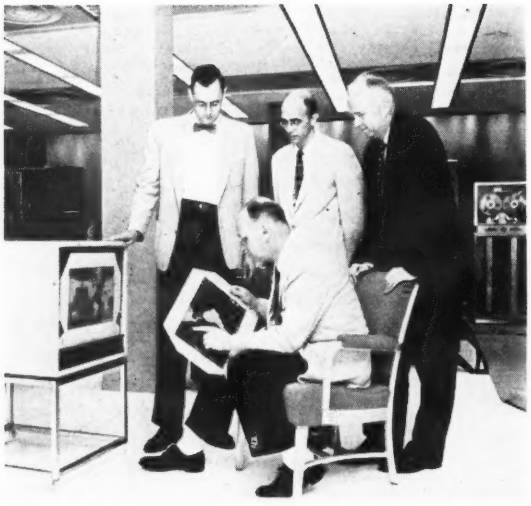
The elements of such a telemetering encoder are square hysteresis loop magnetic cores and switching transistors. The cores are used in two fundamental ways: First, to provide a symmetrical square wave output at a frequency determined by the amplitude of an input signal; second, to generate an unsymmetrical square wave of much lower frequency in which the duration between any two successive pulses is a function of one of a series of separate input signals.

Altogether, 17 separate information sources, including identification and calibration, are coupled to the telemetering encoder. The total number of telemetering channels is 48, to permit repeated samplings of rapidly varying quantities, such as the instantaneous ultraviolet intensity, interspersed between scans of the more slowly varying inputs. The entire 48-channel telemetry encoder weighs about 3.2 oz and requires about 2.8 oz of batteries to provide 4 milliamps at 2.7 volts for three to four weeks of operation.

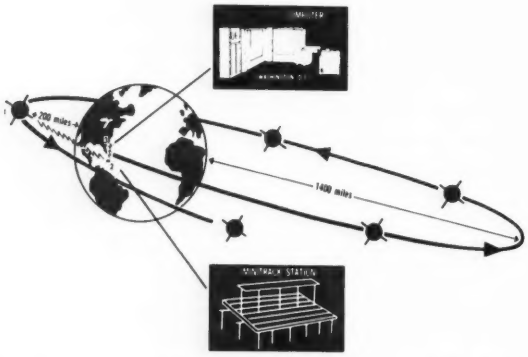
A noteworthy feature of this telemetering system is that all transistors are used as switches operating either at saturation or cut-off except during the instant of switching. In this way power dissipation is minimized and accuracy (CONTINUED ON PAGE 104)

'Brain' to map satellite orbit

Ground computer center will indicate success of project within 90 minutes after Vanguard firing



Scientists at Vanguard computing center examine overlay of earth's surface on which satellite's path will be traced by cathode ray output tube display (left).



How satellite orbit will be computed: Satellite (1) sends radio signal to Minitrack station (2), which relays signal to computer center (3) in Washington.

AMONG the toughest problems facing Project Vanguard scientists are proving that satellites fired are orbiting, measuring these orbits and predicting future orbits. Naval Research Laboratory men working on the project estimate that tracking a satellite is about as difficult as trying to locate a golf ball traveling at sonar speeds 60,000 ft up.

Despite the many difficulties involved, the Vanguard Computing Center, opened last month in Washington, D. C., expects to be able to tell within 90 min after a satellite vehicle is fired whether or not the "moon" is going to orbit.

The brain of the center, operated under a Navy contract by International Business Machines Corp., is an IBM 704 computer with a memory core containing a set of instructions developed by NRL and IBM scientists specifically for orbit calculations.

Data will be fed into the computer from nine U. S. Minitrack stations in this country and in Latin and South America, as well as from an Australian station at Woomera. Within a short period of time, the computer will translate the information into a map of the satellite orbit around the earth.

Will Picture Computer Output

Attached to the 704 is an IBM cathode ray output tube display, which pictures computer output in the forms of graphs, geometrical figures, engineering symbols or words and numbers. Use of the device will permit the satellite's path to be traced on an overlay showing the earth's surface.

Paul Herget, director of the Cincinnati Observatory and an NRL consultant, represents Vanguard director John Hagen at the center. Thomas Horton of IBM is the center manager.

Geodesy comes of age with Vanguard

By providing a fresh approach to classical geodetic problems, it will bring greater advances in the next 18 months than in past 50 years

By John A. O'Keefe

ARMY MAP SERVICE, CORPS OF ENGINEERS, WASHINGTON, D. C.

THERE is every reason to believe that the science of geodesy will make greater advances in the next 18 months, through the use of the artificial satellite, than in the last 50 years. To understand how this can be, it is first necessary to explain exactly what geodesy is.

Geodesy is the business of finding out where things are. This comes down to a matter of measuring angles and distances, usually by means of rays of light or, lately, radio waves.

The difficulty arises from the bending of light by the atmosphere, as in mirages and other manifestations of refraction. In comparison with instrumental accuracies, the bending is colossal. The setting sun, for example, is refracted through 1800 sec of arc, while many modern instruments have errors of a few tenths of a second.

The result of atmospheric refraction is that vertical angles cannot be relied upon over anything except the shortest distances, with the exception of some special observations made simultaneously in both directions over the same line at the same time. Most of the peculiarities of classical geodesy are the result of the effort to avoid measuring vertical angles.

Stated in its simplest terms, the program of classical geodesy is to measure heights above sea level by means of a null method in which the telescope is always level and the curvature of the ray is taken out by balancing the backsights and the foresights; to measure horizontal positions as if they were projected on the sea-level surface, especially its prolongation under the land; and, finally, to discover the shape of the sea-level surface by astronomical and gravimetric measurements. The last step is greatly neglected, since under most circumstances it turns out that practical requirements do not call for knowledge of the sea-level surface. In most of the civilized areas of the world, it is possible to state the height above sea level within a few inches, though the form of the sea level surface is not known within a hundred feet.

All this complex and subtle system of ideas will be shaken up by the launching of the satellite.

The most drastic change is that we will now have vertical angles which can be relied upon. The satellite will appear at elevation angles up to the zenith, in contrast to the typical geodetic targets, which are lights along the horizon. The steep angles mean that less

One of the nation's top geodesists, John A. O'Keefe has been with the Army Corps of Engineers for the past 15 years and since 1945 has been Chief of the Research and Analysis Branch, Geodetic Division, Army Map Service. Now actively engaged in the study of measurement of long distances by means of the earth satellite, Dr. O'Keefe has in the past worked on measurement of long distances, including the distance to the moon, by means of occultations, measurement of intercontinental distances by eclipses and theories of map projections.

atmosphere must be traversed, and hence the errors of refraction are reduced. Moreover, by measuring the satellite against the stars, as Fred Whipple plans to do, it will be possible to determine rather exactly the direction of the long stretch of the ray which lies outside the atmosphere. What little uncertainty remains is in the last mile or so of air. This is a much sounder approach than the ground-based approach of measuring the direction of the last bit of the ray, and deducing the rest by applying refraction corrections, as would be necessary if one-way vertical angles were used in geodesy.

With precise vertical angles, the old separation between leveling and triangulation will lose some of its importance. We will be in a position to solve, in a rather neat way, the old problem of the shape of the sea level surface of the earth.

Measuring Intercontinental Distances

Intimately connected with this is the question of the distances between the continents, or, more precisely, the relative positions of the continents. Our ideas of the distances and azimuths between pairs of points in North America are rather precise; they are accurate within four or five parts per million over distances from 200 miles up to the longest measured arcs in North America. The same is true within those parts of Europe which are connected to European Datum. But the relationship between Europe and North America is not now known within 100 parts per million.

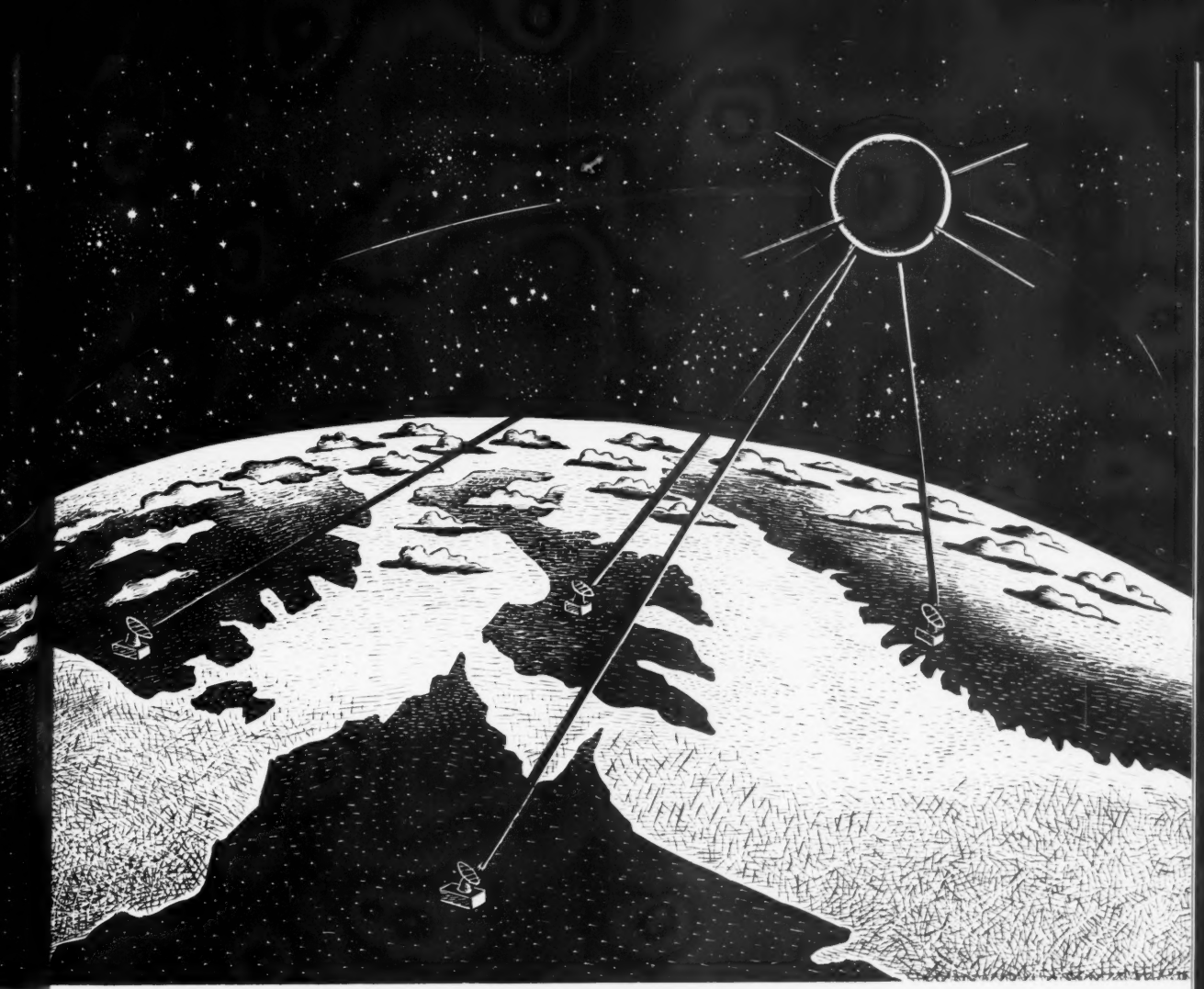
The fundamental reason is that the astronomic determinations give directly only the space direction of the perpendicular to the sea level surface at a point. From this the position is deduced, on the assumption that the sea level surface is a perfect ellipsoid. The deviation of the perpendicular to the sea level surface (i.e., the deviation of the vertical) may amount to as much as 1 min of arc at isolated points. Even over extended areas, deviations of as much as a tenth of this amount may persist. For example, I. Fischer showed that in Europe the slope of the geoid (sea level surface) in the Mediterranean area is systematically about 5 sec different from that of the North German plain.

The satellite provides us with a direct method of attacking this problem, since it will be visible in both continents. Predictions of its path made on the basis of information obtained in North America can be compared with observations in Europe. The discrepancies will reveal the systematic difference between the two continental triangulations. The satellite will thus pave the way for the unification of the triangulation of the whole world on a single datum.

Underlying the single datum there must be a precise figure of the earth—that is, a precise measurement of the constants of the ellipsoid which best fits the sea level surface of the earth everywhere. This is the most ancient of all geodetic problems, the most famous and the one on which the influence of the satellite will be the most decisive.

There are two constants required for the determination of an ellipsoid of revolution. These, in geodesy, are usually taken to be the semimajor axis of the generating ellipse, and its flattening. The flattening is specified numerically by giving the difference between the equatorial and the polar radius, in units of the equatorial radius.

It was pointed out some years ago by Lyman Spitzer that the satellite will yield an extraordinarily good determination of the earth's flattening. The method is one which has been widely used in astronomy to determine the flattenings of the planets. It depends on the fact that the plane of the orbit of a close satellite precesses, owing to the attraction of the earth's equatorial bulge. The same



Tracking the satellite from observation stations throughout the world will provide geodesists with a three-dimensional approach to the problem of large-area surveys, and a new method of measuring intercontinental distances.

effect exists, of course, for the moon, but since the force involved decreases as the cube of the distance, the effects on the moon are much smaller. Moreover, in the case of the moon it is necessary to allow for a similar motion caused by the sun's attraction, which increases in proportion to the distance from the earth. (Naturally the force exerted by the sun does not vary in any such way, but the *difference* between the force on the earth and that on the moon, which is what counts here, *does* vary in proportion to the distance from the earth.) Hence the precession of the satellite orbit will be much faster than the precession of the lunar orbit, and will be nearly uncontaminated by solar influences.

In fact, the motion of the satellite orbit will amount to about 400 miles per day. Since there is a difference of one part in 300 between what the Russians use for flattening of the earth and what the rest of the world uses, it is clear at once that if the motion can be measured even very roughly over the course of a day, we shall have a significant improvement in our knowledge. If we can get accurate measurements over a period of a few weeks, the resulting determination should be of such precision as to put this problem out of the realm of practical geodetic needs.

Determination of Earth's Size

The determination of the earth's size offers more difficulty. The easiest way seems to be through Kepler's third law, which relates the size of the orbit to the period. If we could determine the constant of this law for the earth-centered system, then we could calculate precisely the period of an imaginary satellite skimming the earth at the equator. Since we know from gravity measures exactly what acceleration the imaginary satellite would suffer, we can calculate what the size of the orbit must be to bring the period and the acceleration into agreement. This would be the (CONTINUED ON PAGE 92)

missile market

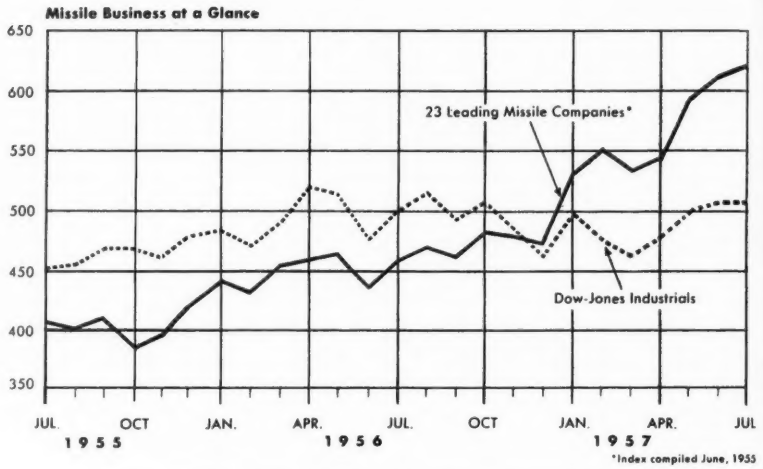
By Robert H. Kenmore

AS FAR as Wall Street is concerned, the Rocket Age has arrived. In April of this year, while the averages were just dawdling along, a number of individual equities started impressive moves on the upside of their own accord. With few exceptions, when tape-watchers looked around for some explanation, the words "rockets" and "missiles" kept coming up. Aerojet (with its parent, General Tire), Marquardt, Thiokol, Bendix, Reaction Motors (and Olin-Mathieson, with its 50 per cent interest) participated in the move, and everywhere you looked, the star performers were the so-called "rocket companies." And so a new stock market fad was born.

But even when this factor became clear—and it is now clear to everyone that the field has grown very interesting to the investor—the problem of selection still remains. Some choices are fairly obvious, and these were the first to participate in concentrated investment demand. However, the rest of the field should not be overlooked.

The first few of these columns will therefore be devoted to an appraisal of various segments of the industry. The first group of companies we'll investigate will be large, well-diversified corporations, heavily in the rocket field and yet in a position to weather any storm stirred up either by the economy or by cuts in defense spending.

Typical of the leaders in this group are Douglas Aircraft, General Dynamics, General Tire and Sperry Rand. Of these, two are among the 25 favorites of investors subscribing to monthly investment plans, instituted by the New York Exchange a few years ago and now numbering over 40,000 members whose choices are followed by Wall Street pros with interest, if not always with reverence. All four are also well represented in institutional portfolios. A statistical comparison of these four companies will be found below. Now let's take a closer look at two of them:



	July 1957	June 1957	% Change	July 1956	% Change
Dow-Jones Industrials	503	505	—0.4	501	+0.4
23 Missile Companies	621	614	+1.1	457	+35.9

Douglas Aircraft—One of the two largest aircraft manufacturers, as well as a top-ranking producer of guided missiles, the latter accounting for 13 per cent of total sales in 1956. Now engaged in eight major missile projects, including Nike-Ajax and Hercules, Thor, Sparrow I and Honest John.

Substantial gains in earnings can be expected as expenses related to DC-8 jet transport development decrease. The Douglas backlog on March 31 stood at over $2 billion, of which half was for military orders, including $215 million for missiles. Payment of the 50-cent quarterly dividend, plus extras, is expected to continue and affords a liberal yield at current prices.

Price-earnings ratio is relatively low and the stock seems reasonably priced.

General Dynamics—Growth through acquisitions and mergers has been spectacular in the past five years. Already five times as large as in 1953, it is likely to make further appreciable gains in sales and earnings for the next few years. Defense work comprises all but a small portion of its sales and will contribute about 85 per cent of 1957 earnings.

The company's Convair Div. is well entrenched in the missile field, and the company is also a leader in the fields of aircraft, electronics, nuclear energy and submarines. It is well advanced in construction of the AF ICBM and is in quantity production of the Navy Terrier missile. GD's two aircraft divisions contributed approximately 70 per cent of 1956 sales. In various development stages are missile-equipped supersonic jets, supersonic bombers.

(CONTINUED ON PAGE 90)

A Statistical Comparison

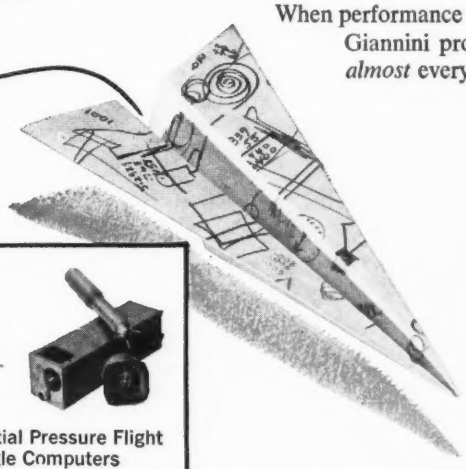
	Fiscal '56 Sales ($ Millions)	Fiscal '56 Earnings* ($ Millions)	Recent Price	Indicated Dividend	PxE† Ratio	Yield (%)	Institutional Holders
Douglas	1,074	8.96	74	$4.00	8	5.4	45
General Dynamics	1,074	4.14	58	2.00	14	3.4	20
General Tire	390	6.91	85	2.00‡	12	2.4	8
Sperry Rand	871	1.83	22	0.80	12	3.6	85

* Per share of common stock, adjusted to present capitalization.
† Price-Earnings.
‡ Plus 4 per cent in stock.

Giannini Instruments and Controls for almost every airborne application

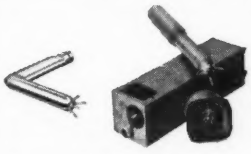
Whether single components or complex packaged systems, virtually all operational military aircraft (and civilian, too) use reliable Giannini precision-crafted instruments and controls.

When performance demands precision, specify Giannini products—they're available for *almost* every airborne application.

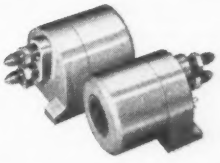


Accelerometers

Temperature Probes



Differential Pressure Flight Angle Computers

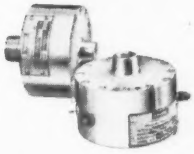


Low Pressure Transducers

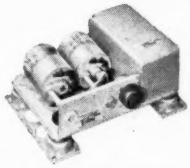
Gyro Instruments

Infinite Resolution Spiralpot Potentiometers

Aerodynamic Angle of Attack Transducers



High Pressure Transducers



Air Data Systems

Fluid Filled Potentiometers

Giannini

INSTRUMENTS · CONTROLS

Engineering positions are open for career-minded young men at several locations—write for details.

REGIONAL SALES OFFICES: NEW YORK 1, N.Y., Empire State Bldg., CHickering 4-4700 • **CHICAGO,** ILL., 8 S. Michigan Ave., ANdover 3-5272
PASADENA, CALIF., 918 E. Green St., RYan 1-7152
FOREIGN SALES OFFICES: LONDON W. 8, ENGLAND, Giannini Limited, 31, Pembroke Gardens

G. M. GIANNINI & COMPANY, INC. • 918 EAST GREEN STREET • PASADENA, CALIF.

ARS news

Northwestern Technological Institute on shore of Lake Michigan

Second ARS-Northwestern Symposium To Look Ahead on 'Transport Properties'

THE AMERICAN ROCKET SOCIETY and Northwestern University will collaborate on their Second Biennial Gas Dynamics Symposium in Evanston, Ill., on Aug. 26-28.

Subject of the five-session scientific parley will be "Transport Properties in Gases," of particular interest to specialists in high speed combustion, but of appreciable concern to all people interested in basic problems of rocket and jet propulsion.

Co-chairmen of this year's symposium are Ali Bulent Cambel, of Northwestern University, and John B. Fenn, of Project SQUID at Princeton University.

The first Symposium took place in 1955 at Northwestern, and dealt with aerothermochemistry. That meeting considerably accelerated interest in the subject on the part of industry, government and universities.

The object of this year's conference will be: (1) To see where the field stands on its ability to define and determine thermal conductivity, viscosity, diffusion and thermal diffusion properties of gases (particularly under extreme conditions); (2) to find out what the present and future data needs are for application design and pure investigation studies; and (3) to point up promising spots where theoretical and experimental research efforts will pay off.

Prime sponsors of the symposium are the Air Force Office of Scientific Research, Army Office of Ordnance Research and the Office of Naval Research through Project SQUID. Industrial sponsors include: Allied Chemical and Dye Corp., AVCO Mfg. Corp., Boeing, Convair, Curtiss-Wright Corp., General Electric, General Motors, Hughes, International Business Machines Corp., International Harvester Co., Linde Co., Lockheed Aircraft Corp., Olin Mathieson Chemical Corp., Phillips Petroleum Co., Ramo-Wooldridge Corp., Reaction Motors, Inc., Republic Aviation Corp., Shell Development Co., Standard Oil Co. (Ind.), The A. D. L. Foundation, Thiokol Chemical Corp., Union Carbide Corp., Westinghouse Electric Corp.

The meeting will be opened by J. Roscoe Miller, president of Northwestern Technological Institute, and Robert C. Truax, president of ARS. Speaker at the symposium banquet will be Brig. Gen. Marvin C. Demler, Air Research and Development Command, Baltimore.

The complete program is as follows:

Monday, August 26

9:00 a.m.

Chairman: Ali Bulent Cambel, Northwestern University, Evanston, Ill.

Theories of Gas Transport Properties, by Joseph O. Hirschfelder, C. F. Curtiss and R. B. Bird, University of Wisconsin, Madison, Wis. (468-57)

Compilations and Sources of Transport Data, by Joseph Hilsenrath, National Bureau of Standards, Washington, D. C. (no preprint)

Collecting, Correlating and Clearing Facilities for Data and Information on Thermophysical Properties, by Y. S. Touloukian, Purdue University, West Lafayette, Ind. (469-57)

2:00 p.m.

Chairman: John B. Fenn, Project SQUID, Princeton, N. J.

On the Direct Determination of the Viscosity of Gases at High Pressures and Temperatures, by J. Kestin, Brown University, Providence, R. I. (470-57)

Determination of Thermal Conductivity, by F. G. Keyes, Massachusetts Insti-

(CONTINUED ON PAGE 80)

AMERICAN ROCKET SOCIETY

500 Fifth Ave., N. Y. 36, N. Y. Pennsylvania 6-6845

OFFICERS

Robert C. Truax, President — George P. Sutton, Vice-President
James J. Harford, Executive Secretary — A. C. Slade, Secretary
Robert M. Lawrence, Treasurer — Andrew G. Haley, General Counsel

BOARD OF DIRECTORS
(Terms expire on dates indicated)

Krafft Ehricke, 1959 — Milton W. Rosen, 1957
Andrew G. Haley, 1957 — H. S. Seifert, 1958
S. K. Hoffman, 1958 — John P. Stapp, 1959
H. W. Ritchey, 1959 — K. R. Stehling, 1958
Wernher von Braun, 1957

TECHNICAL DIVISION CHAIRMEN

David G. Simons, Human Factors — John F. Tormey, Propellants and Combustion
John J. Burke, Instrumentation and Guidance — Brooks T. Morris, Ramjet
Edward N. Hall, Liquid Rocket — William L. Rogers, Solid Rocket
Krafft A. Ehricke, Space Flight

MISSILE SYSTEMS PROPULSION

Weapon systems management activities at Lockheed's Palo Alto, Sunnyvale and Van Nuys organizations call for significant achievement in propulsion. Areas include design analysis, evaluation of test information and technical management of propulsion subcontractors. Inquiries are invited from those possessing a high order of systems ability and strong familiarity with solid and liquid propellant rockets and ramjets. Please address the Research and Development Staff, Sunnyvale 35, or Van Nuys 1, California.

Here Propulsion Staff members discuss problems relating to accurate positioning of a vehicle in the upper atmosphere. Left to right: J. F. Houle, propellant feed systems analysis; B. Ellis, Propulsion Department manager; J. J. Donhan, control force generators.

Lockheed

MISSILE SYSTEMS DIVISION

LOCKHEED AIRCRAFT CORPORATION

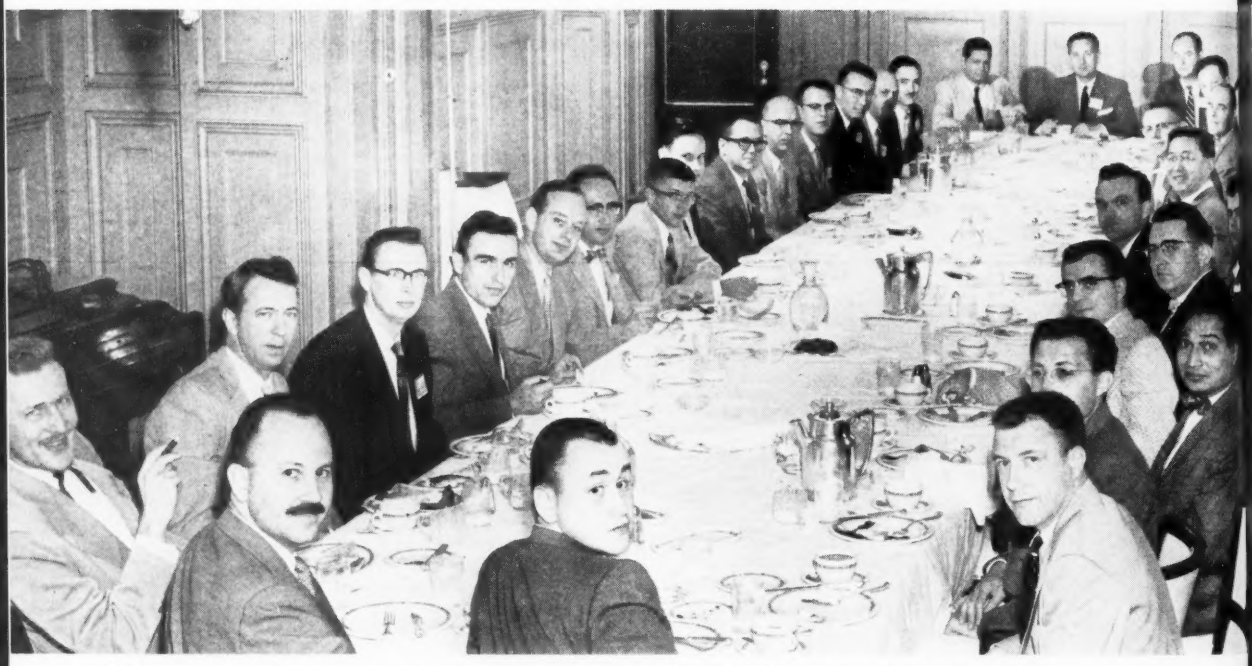
PALO ALTO • SUNNYVALE • VAN NUYS

CALIFORNIA

San Francisco meeting in pictures

Attendance of more than 700 marks successful ARS meeting on Coast . . . Members hear 35 technical papers, enjoy themselves at gala banquet

Early-arrivals buy preprints before opening session.



Authors of technical papers meet for an early morning breakfast-briefing at the St. Francis Hotel.

All technical sessions were well attended. Meeting drew attendance of more than 700.

ARS President Robert C. Truax (seated, right) presides at Board of Directors meeting.

Luncheon speaker was Dan A. Kimball, Aerojet-General president and former Secretary of the Navy.

R. J. Naegele, II, listens to discussion between Truax and Dan M. Tenenbaum at reception.

William F. Ryan, president of ASME, acknowledges Toastmaster Oppenheim's remarks at banquet.

Toastmaster Antoni K. Oppenheim proposes concluding toast as banquet ends.

ARS News

(CONTINUED FROM PAGE 76)

tute of Technology, Cambridge, Mass. (471-57)

Recent Improvements in Thermal Conductivity Measurements and New Values for CO_2 Near the Critical Point, by Leslie A. Guildner, Massachusetts Institute of Technology, Cambridge, Mass. (472-57)

The Measurement of Diffusion Coefficients in Gases and Liquids at Elevated Pressures, by H. H. Reamer and B. H. Sage, California Institute of Technology, Pasadena, Calif. (473-57)

Tuesday, August 27

9:00 a.m.

Chairman: A. K. Oppenheim, University of California, Berkeley, Calif.

Relaxation Phenomena in Gases, by M. Boudart, Princeton University, Princeton, N. J. (474-57)

Solar Furnace Applications to Transport Properties, by P. Duwez, California Institute of Technology, Pasadena, Calif. (475-57)

Molecular Beam Applications to Transport Properties in Gases, by Immanuel Estermann, Office of Naval Research, Washington, D. C. (476-57)

Shock Wave Studies, by S. C. Lin, AVCO Research Laboratory, Everett, Mass. (477-57)

2:00 p.m.

Chairman: R. A. Gross, Fairchild Engine and Airplane Corp., Deer Park, N. Y.

Transport in Jet Engines and Rockets, by Donald R. Bartz, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif. (478-57)

Transport in Aerodynamics, by Robert Bromberg, The Ramo-Wooldridge Corp., Los Angeles, Calif. (479-57)

Transport Information Needed in the Chemical and Process Industries, by Leo Friend, The M. W. Kellogg Co., Jersey City, N. J. (480-57)

Transport in Low Density Gases, by R. S. Sherman, Office of Naval Research. (481-57)

7:00 p.m. Symposium Banquet

Speaker: Brig. Gen. Marvin C. Demler, ARDC, Baltimore, Md.
Subject: The Forward look in Gas Dynamics

Wednesday, August 28

9:00 a.m.

Chairman, John F. Tormey, Rocketdyne, Canoga Park, Calif.

Thermal Diffusion, by Sydney Chapman, High Altitude Observatory, Boulder, Colo. (482-57)

Gas Emissivities and Absorptivities, by S. S. Penner and A. Thomson, California Institute of Technology, Pasadena, Calif. (483-57)

Transport in Ionized Gases, by Marshall Rosenbluth, General Atomic Div., General Dynamics Corp., San Diego, Calif. (484-57)

Left to right are Ali Bulent Cambel and John B. Fenn, co-chairmen of the Symposium and Brig. Gen. Marvin C. Demler of ARDC, banquet speaker.

ARS Adds Three New Corporate Members

Three additional companies active in the rocket, missile or jet propulsion fields have become corporate members of the AMERICAN ROCKET SOCIETY. The new members are:

Consolidated Electrodynamics Corp., Pasadena, Calif. The company makes data acquisition and processing instruments for rockets, missiles, engine test stands, etc., and components for control systems, such as accelerometers, pressure pickups, vibration pickups and amplifiers.

Representing the company in ARS activities are Frank F. Davis, manager, application engineering section, technical services dept.; S. H. Zuck, manager, Pasadena district office; Robert H. Kitson, Manager, San Diego district office; Daniel Robbins, manager, Albuquerque district office; and V. M. Meagher, manager, Atlanta district office.

Varian Associates, Palo Alto, Calif., whose activities center on the design and manufacture of microwave tubes for use in rocket navigation and control.

Named to represent the firm are C. W. Carnahan, technical assistant to the president; Fred Wilimek, contract administrator; Gen. Frank E. Stoner (Ret.), director of program planning; Col. Walter Brown, government relations advisor; and H. Myrl Stearns, president.

Telecomputing Corp., Van Nuys, Calif. Active in the fields of missile guidance, gyros, electronic equipment, data reduction and handling systems, and missile systems.

Representing the company are A. C. Cocagne, vice-president, field engineering; W. C. Penzel, eastern zone manager; Ward Beman, general manager, Whittaker Gyro Div.; Bill Bennett, vice-president, engineering, Whittaker Gyro Div.; and George Brubaker, president.

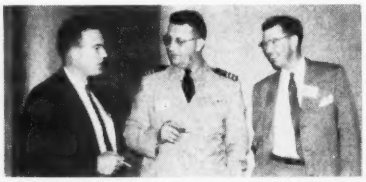
No Visas Required for IAF Barcelona Meeting

There will be no need for U. S. citizens planning to attend the eighth annual congress of the International Astronautical Federation in Barcelona, Spain, Oct. 7–12, to obtain visas for the trip.

Hotel reservations can be made through Thomas Cook & Sons, which has branch offices in most major cities.

1957 Nuclear Congress Proceedings Available

"Proceedings of the 1957 Nuclear Congress" will be published Aug. 15 by ASME. The three-volume work is available to members of the AMERICAN ROCKET SOCIETY, one of the sponsors of the congress, at a pre-publication price of $35, representing a $10 saving, if ordered before that date.



Two guest speakers helped to make Detroit Section's annual meeting a huge success. In photo at left, Cdr. R. F. Freitag is flanked by program chairman D. N. Buell (left) and retiring president C. W. Williams. In photo at right, (l to r), president Williams, guest speaker Kurt Stehling and president-elect Lovell Lawrence.

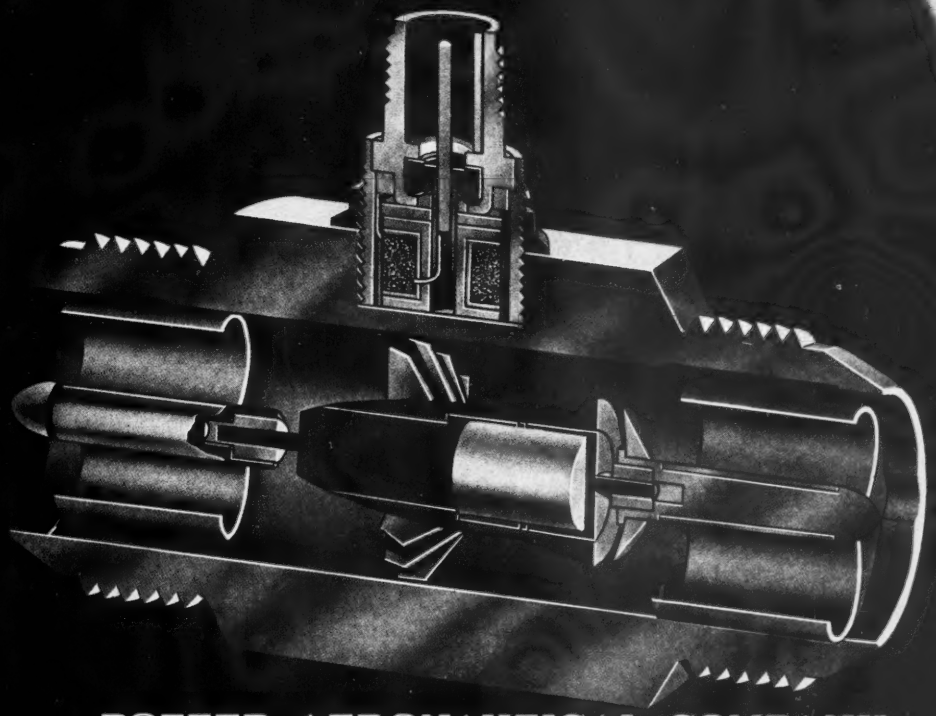
A.D. 1959

Flow Control by POTTERMETER

In every major development project using liquid propellants, such as long range rockets, satellite launching vehicles, high performance aircraft—Pottermeters are used for precise flow control. Potter flow meters are accurate and reliable even under extreme conditions of temperature, pressure, vibration and shock.

Potter, pioneers in precision flow control, may be able to assist you in your flow metering or flow control problems.

Send us your inquiry or write for Bulletin S-1.



POTTER AERONAUTICAL COMPANY

Route 22 · Union, New Jersey

ASME Membership Offered Without Entrance Fee Payment

AMERICAN ROCKET SOCIETY members can now join the American Society of Mechanical Engineers without paying an initiation or entrance fee. Under the terms of an agreement approved by both the ARS and ASME, a member of either society may join the other society without payment of such a fee to the second society.

In each case the member of the first society must present his application for membership in the second society and meet its membership requirements.

Elimination of entrance fees in the second society will apply only to the fee for entrance at the equivalent or lower grade. If the applicant to the second society is upgraded, the promotion fee will be paid. The Fellow grade in both societies is upon nomination or invitation.

Each society will permit Student Members to become members in a suitable grade without paying entrance fees upon graduation. Under the agreement, a student who has transferred to the suitable grade in his society may apply for entrance in a suitable grade in the second society and, upon acceptance, take the grade without entrance fee.

ARS SECTION PRESIDENTS

Cliff E. Fitton Jr., Alabama
Richard A. Schmidt, Antelope Valley
Sydney Wade, Arizona
John R. Youngquist, Central Colorado
E. F. Fiock, Central Texas
John Krc Jr., Chicago
Luis R. Lazo, Cleveland-Akron
Abbott A. Putnam, Columbus
Charles H. King Jr., Connecticut Valley
Lovell Lawrence, Detroit
R. L. Yordy, Florida
Roy Jackson, Fort Wayne
Gerhard R. Eber, Holloman
W. H. Munyon, Indiana
Samuel Fradin, Maryland
Erik Bergaust, National Capital
Lawrence Levy, New England
George L. Meredith, New Mexico-West Texas
Robert A. Gross, New York
Harry A. Ferullo, Niagara Frontier
T. C. Swartz (Acting) Northeastern New York
A. K. Oppenheim, Northern California
George H. Craig, North Texas
W. Emmett Coon, Pacific Northwest
Abe Bernstein, Philadelphia
John B. Fenn, Princeton
C. M. Shaar Jr., St. Joseph Valley
Daniel M. Tenenbaum, Sacramento
Robert A. Cooley, St. Louis
Krafft Ehricke, San Diego
James A. Broadston, Southern California
T. P. Meloy, Southern Ohio
C. C. Chang, Twin Cities
Kenneth Kerr, University Park
Lawrence J. McMurtrey, Wichita

ARS STUDENT CHAPTER PRESIDENTS

Frank Ford, Academy of Aeronautics
Morton Metersky, Georgia Tech
Robert E. Huber, New York University
Gerald Chmielewski, Parks College of Aeronautical Technology
Paul Cooper, Polytechnic Institute of Brooklyn
Richard Nelson, Stevens Institute of Techology
J. B. Bullock, University of Michigan

SECTION NOTES

Detroit: The annual meeting of the Detroit Section, held in the Rackham Memorial Building of the Engineering Society of Detroit, and marked by the appearance of not one, but two, guest speakers, as well as the announcement of new officers, was a huge success. Dinner was served to over 140 people, and afterwards the group adjourned to the auditorium for the business meeting and the addresses by Cdr. R. F. Freitag, Office of the Chief of Naval Operations, Washington, and Kurt Stehling, Naval Research Laboratory, Washington, and ARS National Program Chairman.

Cdr. Freitag, speaking on "The Outlook in the Guided Missiles Field," reviewed the entire field, noting that we are now entering an era which will see continued improvement of present missile systems, along with the development of new systems, such as the anti-missile missile, while work is also initiated in the peaceful aspects of rocketry, "exploiting the knowledge and techniques developed in guided weapons to provide new scientific achievements and improvement of world living standards."

Preceding the meeting, a reception was given for the guest speakers by Chrysler Corp.

At the business meeting, Frank Swaney, chairman of the Tellers Committee, announced the election results. Lovell Lawrence Jr., assistant chief engineer, missile design, Chrysler Missile Operations, was elected president. Retiring president C. W. Williams, also of Chrysler Missile, was named to the board, along with Carl Bachle and Arthur Nichols.

Other officers for the coming year are C. W. Tait, vice-president; E. A. Nielsen, secretary; and Jack Squires, treasurer.

New York: The New York Section recently substituted a field trip to the U. S. Naval Air Turbine Test Station at Mercer County Airport, West Trenton, N. J., for its regular monthly meeting. The Navy acted as host in a presentation of the facility and tour of the station, followed by a luncheon.

The station, built on a 200-acre site at a cost of $41 million, was constructed for the purpose of testing turbojet, ramjet, pulsejet and turboprop engines by industry and the military. The tour showed how such engines are tested at all environmental conditions from sea level to 65,000 ft and at the extremes of temperature and humidity found at these altitudes.

Northern California: The flair for "Toastmastership" displayed by Antoni K. Oppenheim, president of the Northern California Section, at the ARS Semi-Annual Meeting banquet in San Francisco inspired Walter Medeiros to come up with the following bit of doggerel:

ODE TO TONY ON THE MORNING-AFTER-THE-NIGHT OF THE ARS BANQUET

an engineer,
a rocketeer,
is Tony Oppenheim.

like a scientist true
he can speak to you
about space and matter and time.

yet his talents surpass
mere knowledge of gas
with a quality more sublime.

for the soul of a poet
(oh who can bestow it!)
resides in his wit with a rhyme.

Southern California: J. L. Murphy, supervisor, rocket vehicles group, Coleman Engineering Co., Inc., Los Angeles, was the guest speaker at last month's meeting of the Southern California Section. Murphy's interesting talk centered on "Project SMART" and the use of rockets and rocket-powered sleds for the testing of all forms of escape systems from high speed aircraft. His presentation was supplemented by movies of some unusual sled runs and a film entitled "Supersonic Survival."

STUDENT CHAPTERS

Georgia Tech: Morton Metersky has been elected Executive Chairman of the Georgia Tech Student Chapter for the coming year. Other officers are Marvin Gechman, executive vice-chairman; Michael Madden, corresponding secretary; Arnold Cohen, recording secretary; and Bob Smith, treasurer.

The chapter is planning a field trip to the Army Ballistic Missile Agency in the near future and is also planning a project for the fall with the assistance of Mario J. Goglia of the mechanical engineering department at the school.

DIVISIONS

Human Factors: Make-up of the Human Factors Committee has just been announced by Maj. David G. Simons, Division Chairman. Committee members are:

Col. John P. Stapp, Aero Medical Field Laboratory, Holloman AFB, N. Mex.; Dr. Irwin Cooper, Rand Corp., Santa Monica, Calif.; Lt. Col. Rufus R. Hessburg, Aero Medical Laboratory, Wright-Patterson AFB, Ohio; Cdr. George Hoover, Office of Naval Research, Washington, D. C.; Cdr. A. L. Hall, School of Aviation Medicine, Naval Air Station, Pensacola, Fla.; Dr. Arnold Small, Human Factors Staff, Convair, San Diego, Calif.; Dr. E. B. Konecci, Tulsa, Okla.; and Capt. Grover J. D. Schack, Aero Medical Field Laboratory, Holloman AFB, N. Mex., Dr. Herman J. Schaefer, School of Aviation Medicine, Naval Air Station, Pensacola, Fla.

New Electronics Facility Opened by Sperry Rand

Clearing the way for operation of its new Electronics Div. at Clearwater, Fla., Sperry Rand Corp. has leased space at Dunedin, Fla., opened an employment office and begun transferring key personnel to the area.

The new operation represents an expansion of the company's facilities for the development and testing of new microwave and electronic instrumentation designed to control and monitor functions in aircraft and missile systems. Rudolf Henning will be in charge of technical operations for the division.

Construction has already begun on a 75,000 sq ft plant near Clearwater, with operations scheduled to get under way about the end of this year.

ICBM: Giant Step into Space

(CONTINUED FROM PAGE 41)

ous ensemble to meet military requirements.

The parallel efforts had to represent different approaches, yet had to be complementary and of maximum aid to one another. For instance, the propulsion system for Titan should also work for Atlas; the nose cone of Atlas should be operative on Titan. Further, it was frequently necessary for these programs to utilize common contractors. Thus, with the exception of the airframe contractors, the IRBM program uses subsystem hardware and contractors from the Atlas and Titan programs. All three programs use common government facilities to a considerable extent, including common flight-test ranges.

The very size and cost of the whole program exerts a control on the extent to which parallel approaches can be tried. Although every effort was made to plan these programs so as to utilize the existing art, and thus eliminate uncertainty as to success, the boundaries between what is known and unknown in the technical art are being regularly pushed back by supporting research efforts designed deliberately to provide a substantial safety factor for all three projects. Wherever there is any major question as to which approach is the best, this implies that the results from one team's effort should be allowed to benefit the work of the other teams.

All aspects of organization—selection of contractors, distribution of responsibility among them, setting up of teams—were based on the objective of earliest operational capability. However, it was only realistic to recognize that the projects would continually need evaluation and modification so as to minimize any threats to success and to exploit any newly acquired information. Also, no program requiring so many new facilities, from special environmental equipment to elaborately instrumented ranges going out thousands of miles, could be planned initially with such foresight that detailed alterations of plans would never be needed. In fact, to try to hold to such an objective could be a great handicap.

Communications Web Was Needed

Accordingly, it was seen that the central management organization would not only initially require sufficient scientific and systems engineering strength to work with the military in the creation of the research and development plan, but would also have to be in a position to control any major aspect of the program in the light of what was happening at any given time. A web of communications needed to be set up, converging in one central source competent to evaluate the information and to provide proper direction to all team members. Even the initial relationship between

Air-Borne Redstone

Heavily padded Redstone missile is eased into AF Globemaster in Michigan before being flown to Patrick AFB, Fla., for test firing. Redstone is largest missile ever to be shipped by air.

Aeroscience inc.

AERODYNAMICS
TEST PROGRAMS
PROPULSION SYSTEMS
WIND TUNNEL & MODEL DESIGN

Aeroscience gives the aviation and missile industry a versatile 'extra hand' in design engineering and fabrication services. Engaging in prime and sub contracts for design engineering and fabrication of propulsion systems, wind tunnel testing and aerodynamics, AEROSCIENCE has the proven experience and ability to do the job . . . and more . . . on time.

Engineers interested in joining this growing company please contact Mr. Joseph F. Ganahl, President.

3155 NO. ROSEMEAD BLVD., ROSEMEAD, CALIFORNIA
ATlantic 0-2112

military requirements and the performance specifications would require regular reviews, and modifications to attain an earlier result would always have to be weighed against a competitive method using a later but superior result. Planning, monitoring and optimum assignment of facilities was seen also to be a major effort for the central management organization.

Would Have Prime Responsibility

Moreover, in view of the plan to parallel the research and development with production planning and complete operational implementation, it was evident that a large amount of central management's internal activities would have to do with interactions among the technical, operational and procurement aspects. Above all, it was clear that a systems engineering organization would be required to do systems design and analysis and to exercise prime responsibility for overall performances that meet the military requirements.

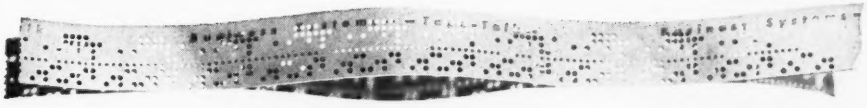
The communications problem for so large a program presents a real challenge, and a great deal of attention had to be given to arranging the program's operations so as to minimize this disadvantage. An important compensating factor has been the centralization in one geographic location of the Air Force authority and control, embodied in the Air Force Ballistic Missile Div., ARDC, as the executive agency, and the Ballistic Missile Office, AMC, as the procurement agency, together with the systems engineering and technical direction organization —the Guided Missile Research Div. of The Ramo-Wooldridge Corp.—in one set of buildings, with higher echelons of government supporting and decentralizing to this program-management team.

Previous Art Was Used

Some general remarks relating the ICBM and IRBM technical problems to those of other missile programs may help to show how advantage was taken of the previous art. Roughly speaking, the counterpart, in the sense of a previous technical step, can generally be found spread over the entire guided missile, aircraft and electronics art. Thus, a ground radar that had nothing to do with guided missiles in the past furnished the basis for an extension for some of the ICBM system. Something similar can be said with regard to ground digital computers. Some techniques and components came out of aircraft, others out of short-range ballistic missiles and still others from surface-to-air and even air-to-air missiles.

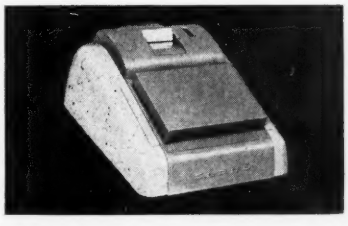
0.0999

EITHER WAY OR BOTH

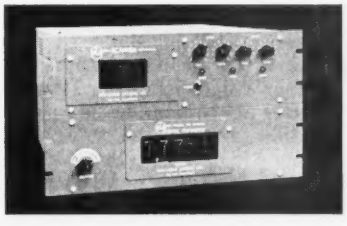


...in a clear numerical form or a printed record NLS gives you rapid, accurate electrical measurements.

The vital accuracy in electrical measurement instruments that today's exacting sciences demand is provided by Non-Linear Systems, Inc. Not only are NLS digital instruments unsurpassed in speed, dependability and long life, but their visual readout performance may be supplemented by printed data recorders. Thus, visual reading may be done by unskilled personnel while printed or punched paper data is also recorded for future study. Complete, pre-engineered automatic test systems can be established by adding input scanners to NLS digital instruments, permitting sampling of up to one thousand stations. Oil immersed stepping switches – an exclusive NLS feature – assure constant accuracy and trouble-free long life of both NLS digital voltmeters and ohmmeters. The NLS line of digital instruments covers a wide range of engineering and scientific electrical measurement applications. Whatever your needs in this field, NLS can meet your most exacting requirements in instruments and systems. Your inquiry will be welcomed.



Clary Printers (both 8 column and 11 column) are supplied by NLS to be used in connection with DC digital voltmeters, 4 digit and 5 digit AC/DC voltmeters or ohmmeters.



Input scanners used with NLS digital voltmeters or digital ohmmeters provide for automatic scanning of many inputs and when used with data recorders provide complete automatic systems.

Flexowriter equipment for typewriting of data and simultaneous paper tape punching may be used with NLS digital voltmeters and ohmmeters. NLS Flexowriter converters are provided for this purpose.

Originators of the Digital Voltmeter

NLS **non-linear systems, inc.**

San Diego County Airport, Del Mar, California, Dept. J-857
Sales Engineering Offices in Los Angeles and Cleveland

See us at WESCON in Booth Number 3003

Digital Ohmmeters • AC-DC Converters • Data Reduction Systems • Digital Readouts
Peak Reader Systems • Binary Decimal Converters • Digital Recording Systems

The illustration on page 41, which shows to scale a few of the trajectory characteristics of ballistic missiles for three ranges, taking a 5-to-1 step each time, from 200 to 1000 to 5000 nautical miles, suggests that some very substantial differences should exist between short- and long-range missiles. On the other hand, a number of factors do not change very much between very short- and very long-range missiles.

In making the major technical decision, a notable effort was made to bring in the experience of all the leaders of the guided missile and associated art. As an example, for the testing plan, experts from earlier programs either joined the present one or were brought into key discussions. Some believed the best way to move rapidly was to analyze every test completed and to use all the results to make improvements before attempting a next test. Others argued that, without a set of tests that would provide statistical and confirming evidence of faults, no solid progress could be made. Many had experienced their worst problems in the past when they tried to reproduce results and wanted special emphasis on catering to the fabrication and assembly problems from the outset. Others felt substantial redesign could be tolerated. Judgment as to technical risk in skipping steps to save time varied, of course. But we had the assistance of most of the experts and the facts of the past to help us.

To give adequate credit to personnel and organizations who have or are now participating would require a separate article. Suffice it to say that practically every aircraft, electrical and electronics organization, government laboratory and agency, university and non-profit foundation, was consulted, and that most are either participating or have furnished data and experiences for consideration.

Past Experiences Interpreted

All of these past experiences naturally had to be interpreted in the light of our specific problems. Many approaches that looked good on other projects were seen to be less than optimum for this one, because the priority and support of this project made possible even better avenues that would not have been possible elsewhere.

Now let's consider specific technical fields. First, propulsion. The need for large-thrust rocket engines is clear because a long-range ballistic missile of operational usefulness must bring heavy payloads up to a power cutoff velocity of 15,000 to 25,000 fps.

Boeing Stratotanker Takes to Air

The first Boeing KC-135A jet Stratotanker to be placed in operational service with SAC has been delivered to the 93rd Air Refueling Squadron at Castle AFB, Calif. The plane, first jet tanker-transport model to be ordered by the Air Force, is powered by four Pratt & Whitney J57 turbojet engines.

However, such rocket engines had been under development for about 10 years by the Air Force at North American's Rocketdyne Div. for use in both long-range ballistic missiles and long-range strategic missiles of the air-breathing type, in the latter case as boosters.

The propulsion program has since been expanded to include other pioneer organizations, with Aerojet-General as the major added contractor. American Machine and Foundry is a principal contractor for auxiliary power supply.

When the Air Force ICBM program was accelerated, this engine work was seen to provide the best possible basis for extension and rapid reduction to practice. As a matter of fact, components of the ICBM engines provide the propulsion system for IRBM missiles as well, with both the Air Force Thor and the Army Jupiter IRBM using these identical engines from the same production line. Thus the manifold expansion in resources which the ICBM program had earlier placed in motion to accelerate the availability of these large rocket engine components was a major factor in the determination of estimated schedules for the IRBM programs.

For thrust control of the ICBM and IRBM, both as to cutoff and thrust vector orientation, use was made of the background experience of various organizations in the country. In particular, a basis for the swiveling of the rocket engines to control thrust vector orientation was provided by the Air Force's work on the Project MX-774 surface-to-surface missile, performed by Convair, and on the Bomarc surface-to-air missile, performed by Boeing, and also by the Navy's Viking program for upper atmospheric research, performed by the Naval Research Laboratory and The Martin Co.

Structure problems with long-range ballistic missiles are severe for several reasons. Keeping structural weight to a minimum is much more critical than it is for most other flight vehicles. In addition, the structure must withstand high accelerations and speeds, and extreme conditions of air density and temperature, and high Mach numbers are reached in regions of substantial air density and with considerable temperature differences between the outside and the inside of the structure.

The structural problem is somewhat less severe in the case of the IRBM. Of course, it is possible to design a short-range surface-to-surface ballistic missile so that the structural weight is very critical, with the range falling off badly from the design requirement when and if the structure has to be made somewhat heavier because of unanticipated problems. However, as a function of range, it is very much easier with today's art to overdesign rangewise for the shorter-range ballistic missiles. As one increases the range to intercontinental proportions, it becomes increasingly more difficult to choose all the other parameters so as to allow for generosity in the assignment of weight to the structure itself.

Faces Similar Problem

The problem has considerable similarity to that of the long-range, high speed airplane, where the designer also reaches a situation where a small difference in structure can make a large difference in performance of the aircraft.

The detailed design of such large, lightweight structures and the physical integration of all components into the structure have been part of the successful operations of aircraft companies for years. It is not surprising that the Air Force has chosen some of the most experienced of these companies to handle the structure and physical integration role.

The guidance and control problem for the ICBM is similar to that for certain surface-to-air missiles, as well as shorter-range surface-to-surface missiles. In a ballistic missile, the problem is to attain the proper vector velocity at the end of a relatively short powered flight path. Whether this is done by measuring the motions of the missile with on-board accelerometers mounted on stabilized platforms, or by the use of radio measurements made from the ground, or by some of both, the problem is similar to that

THE BIG STICK

Since 1946, Martin engineering has placed special emphasis on the science of rocket and missile development.

It is because of this that Martin is now building a most potent and important weapon system—the ICBM Titan—an ocean-spanning missile to back up the traditional American policy of peace with honor: *"Speak softly and carry a big stick!"*

From this intercontinental peace protector to the world's first satellite launching vehicle now nearing completion, Martin engineering is pioneering the new age of missiles and rockets.

If you are on the watch for tomorrow, watch Martin today.

MARTIN

BALTIMORE · DENVER · ORLANDO

of a surface-to-air missile which must traverse a limited region of space with the proper timing and velocity to intercept its target.

Of course, there is great similarity between long- and short-range ballistic missiles. But one must be careful here in making the extrapolations, because in general the instrumentation errors as seen at the target grow much more rapidly than with range. Also, the distances for communication from ground to missile can be very substantially greater, so that the communication components do not necessarily have the range to permit them to operate with comparable performance, if at all. A gyro carried by the missile has less time to accumulate a drift error in the shorter boost time of an IRBM than is true with an ICBM. In addition, for the same accumulated drift at the end of powered flight, the error is greater at the target for vector range.

Could Be Applied to IRBM

Thus, certain guidance and control components that were already under development for the ICBM could be readily applied to the IRBM with a relaxation of component performance specifications.

Radar and computer equipment has been an important aspect of the defense program of the military services for many years. Some of these major contractors, including General Electric, Bell Telephone Laboratories, Western Electric, Sperry Rand and Burroughs, are now engaged on behalf of Thor, Atlas and Titan.

Other projects have furnished substantial background on precision inertial components. The requirement for low drift in the gyros, for example, arose in previous long-range strategic bombing and navigation work, both for manned bombers and jet-propelled guided missiles. In such past developments, the gyro drift rate had to be kept exceedingly small so that the cumulative effect for the longer flight time would not impair the final result. In the case of the same miss by a ballistic missile and by an aircraft-type missile of intercontinental range, for example, it is the latter that requires the higher accuracy in the sense of freedom from drift, by a factor of more than one order of magnitude.

Of course, gyro drift is not the only, or even the major, source of error. But it could be a major source if we were not in a position to apply available high-grade precision gyros that have been under development for many years for aircraft systems as well as missiles. Fortunately, the same inherent mechanical design features that free these instruments from error also make them very rugged. They do not fall apart under the higher acceleration of the ICBM. Several organizations that have had a decade of successful experience with precision inertial components and stabilized platform work are now heavily involved in the Thor, Atlas and Titan programs. Among these are the Instrumentation Laboratory at MIT, AC Spark Plug Div. of General Motors and Arma Div. of American Bosch Arma.

To say that the ICBM re-entry problem is unrelated to any past developments is an overstatement, of course, but let us take it as a starting point. Initially, we had no experimental results on any missiles or airplanes for the required ICBM conditions. The problem here includes one of high heat rate, but for a short time. Not even meteorites provide us with comparable data, although some useful clues can be obtained from them.

The problem was first attacked with an intensive theoretical exploration of the fundamental processes involved. This effort, one can say with only slight exaggeration, enlisted the combined hypersonics and heat transfer talent of the nation with background on the problem, through direct involvement with the leading workers in many universities, government agencies and industrial organizations, including especially NACA and the California Institute of Technology.

Theoretical extension of such experimental work as existed, mainly for lower Mach number conditions, next suggested experiments to confirm the theories, and these were set up in several organizations. To date, highly significant experimental work has already been accomplished on this program by Avco with large shock tubes and by Lockheed with multistage re-entry test vehicles. These experimental results have confirmed the extended theory and provided the basis for re-entry vehicle design. "Nose cones" for the vehicle are being developed and produced by General Electric and Avco.

Included in the experimental work was a series of multistage test missile launchings (12 perfect flights occurred in succession!), from each of which comprehensive and important pioneer data on re-entry were obtained.

Of course, all missiles, except perhaps some subsonic ones, encounter the problem of heating, and for some the heat rate is so high as to require major attention. However, the problem can be minimized by proper choice of parameters in the short-range ballistic missiles, for example, and in most surface-to-air and air-to-surface missiles. It is safe to say that use was made of every bit of pertinent experimental data and every applicable formula that could be found as bases for extrapolation to the unprecedented ICBM situation. For the IRBM, the problem is easier, but still much tougher than for missiles in general.

Makes Space Conquest Possible

The relationship of the ICBM to future developments is partially indicated by noting the power cutoff or escape velocities required for short, medium and intercontinental ranges, for earth satellites, for reaching the moon and for reaching Mars, indicated in the table on page 41. We see that each velocity requirement differs by a decreasing percentage from the next slower one. The ICBM, with its capability of imparting a high velocity to large payloads, essentially makes space conquest possible. In so far as propulsion and velocity are concerned, future projects appear to be almost attainable with ICBM hardware merely by reducing the payload somewhat.

As for the accuracy of guidance, something similar can be said. It is easier to hit the moon than to hit a

Last of the Vikings

Viking 14, the second Vanguard test vehicle (TV-1), gets final check before firing. Of note here is the unusual nose configuration, unclear for the most part on other published photos of the missile.

militarily useful target several thousand miles away from the launch point. The ICBM can therefore be considered a major step toward true outer space technology, especially if one limits consideration to unmanned payloads.

Something too often in the background in space technology discussions is the problem of getting from the surface of some planet, say the earth, out to space and getting back down safely through the atmosphere. What happens in empty space, which takes up most of the flight time, may always be less important from the engineering standpoint than what happens in getting up through the atmosphere to the necessary escape velocity and in getting back down. In these respects, the ICBM is solving a major fraction of space technology problems for unmanned instrumented flights. This would not be the case if the ICBM payload were small, for there is a great difference in difficulty and in complexity of task as a function of size of payload. The ICBM payload is large enough to cross over into the region of maximum interest.

Another future step increasing payload requirements even more would be to have human passengers carried through distant space, especially in relatively short times. Because of the passengers and all their equipment, and also because of the indirect problems associated with the length of time of such flights, the increase in payload probably will be one order of magnitude over the ICBM. Furthermore, because ICBM accelerations are much too high for human passengers, the large ICBM engines would have to be controlled and throttled in a different fashion.

May Make For Faster Progress

If we seek space conquest for scientific, commercial, or military purposes—whether for world TV relays, weather prediction, or cosmic ray or other physical measurements—certainly this can be done earlier and probably more economically with unmanned, instrumented vehicles. If at present we concentrate on instrumented space vehicles, instead of on those carrying passengers, we may conceivably make much faster progress in space technology. The coming space age may largely deserve to be an instrument-passenger kind of era. The space age may come faster if it is so recognized.

The foregoing remarks about the future, based on ICBM experience and accomplishments, have touched mainly on technical state-of-the-art advances. What of management and organization? Does the present kind of unique management setup offer a solution to the problems of how to get large systems engineered and directed?

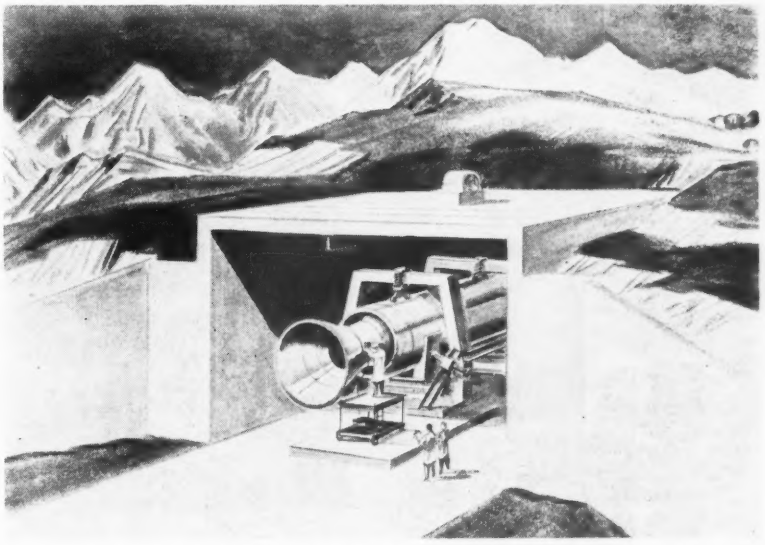
The writer can only give his own opinions. One of them is that "there is more than one way to skin a cat." Not every big project would appear to need a special management-systems-engineering group such as exists for the AF ballistic missile programs. More often, the systems engineering task can be effectively carried out by one of the major industrial contractors engaged in producing part of the system, perhaps an aircraft manufacturer if the system hinges on aeronautical or structural aspects, or an electronics manufacturer if transfer and control of information are the critical aspects. At other times, the answer may be a group of associate contractors, with the systems engineering held by the government.

For the present management-technical-direction scheme to be appropriate on some future project, some of the exceptional conditions that brought the present one about would have to reoccur. These would include a crash effort requiring many large, competitive industrial firms; exceedingly broad advances in the technical art; radical change in military operational techniques brought about by the new system; overlapping of development, production, and operational preparation; urgency justifying high priority in channeling of resources; and major, widespread and novel government facilities. Under these unusual circumstances, the present AF arrangement, combining under one roof a capability for over-all management, procurement, systems engineering and technical direction, for visibility and evaluation of all progress, for analysis of performance versus requirements and for assessing technical risk versus funds and urgency, would appear a good way to do the job.

The cost of systems engineering and technical direction on the ICBM and IRBM programs is about 2 per cent of total costs. It will be an even smaller percentage when later production costs are added after the systems engineering is finished. Whatever arrangement is adopted for any future project, the quality of the systems engineering and the objectivity and competence of over-all technical direction obviously can have an effect on the result far beyond the cost of these tasks.

Evidently the organization of the direction of any important project merits considerable thought.

New Thiokol Test Stand: Bigger, More Rugged



Artist's rendering of Thiokol's 2 million lb thrust Utah stand

Static rocket test facilities capable of handling solid propellant engines up to 12 ft in diam and designed to resist 2 million lb of thrust are now in operation at Thiokol's Utah Div. in Brigham City. The new horizontal stand is said to be the largest solid propellant facility in the country.

The test section is the first part of the Utah facility to be completed, with the manufacture of rocket engines slated to get under way in the fall. The Utah Div. was recently awarded its first production contract by the Air Force, for rocket booster engines for the Martin TM 61B Matador, now being produced elsewhere by the company.

Missile Market

(CONTINUED FROM PAGE 74)

military transports and commercial aircraft.

On March 31, GD's backlog was about $2.2 billion, with an additional $650 million worth of contracts under negotiation. Sales in the current year should again show a substantial gain, with earnings rising proportionately. The present 50-cent quarterly dividend rate stands a good chance of being increased.

Next month we'll examine the other two companies and then we'll go on to appraise some companies which are smaller and less diversified than these giants, but which also stand to gain more directly from the growth of the missile business because their fortunes are more closely tied in with it.

Market Letter Gleanings

Northrop—"At its present price, risk is small by comparison with the stock's inherent potential of major capital gains." (Forbes)

Raytheon—"The common stock has been hitting new highs recently. This can be attributed primarily to increased interest in the stock among other investment houses . . . and to an increased general interest in the missile program." (Bear, Stearns)

Thiokol—"While the stock has more than tripled in price since August 1952, earnings last year were five times greater and will be much higher this year and next. We consider Thiokol the most attractive issue for participation in the tremendous growth believed to lie ahead in the field of missiles and related components." (Eastman Dillon)

American Bosch Arma—". . . offers interesting capital gain possibilities at current levels (for) accounts willing to assume the moderate risks involved." (Hemphill, Noyes)

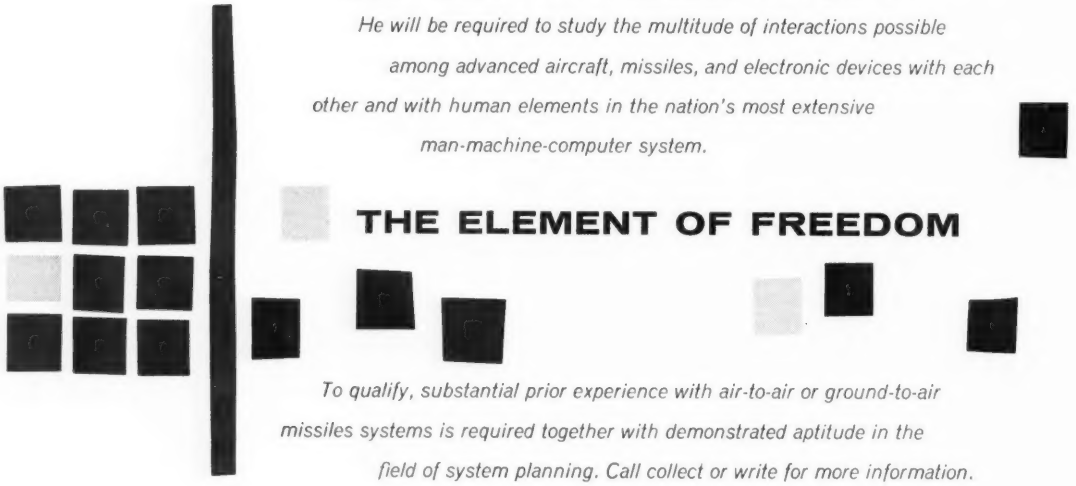
Martin Co.—"Considered an attractive situation for those willing to exercise patience." (Standard & Poor's)

The Missile Industry—"Among the missile contractors, General Dynamics, Martin and Douglas are considered to have a decided edge, competitionwise, as their principal weapon projects are expected to reach a full production stage in the near future. In the field of missile engines, we favor General Tire & Rubber, North American Aviation and United Aircraft. Of the producers of guidance systems, the best-situated companies appear to be American Bosch Arma, Bendix, Raytheon, Ryan, Sperry Rand and Thompson Products." (Newburger, Loeb)

Financial Briefs: Aerojet sells $7.5 million worth of stock privately, plans at least 10-for-one split within a year . . . Chance-Vought offers $17.5 million $5^1/_4$ per cent convertible debentures . . . Emerson plans $3.4 million of converted subordinated debentures . . . Thompson Products president expects 1957 net to be around last year's $4.60 a share. Direactors will probably consider boost in common stock dividend later this year. . . Boeing sees 1957 profits up, but below rate of sales gain. . . Air Products plans offering of 170,160 shares of common stock. . . Marquardt paid 100 per cent stock dividend July 1.

Freedom is doing what you like. Some engineers like best to match their wits and skill against difficult technical problems.

This characteristic (or idiosyncrasy) of liking complicated technical problems will be one of the chief qualifications of the engineer we need. He will be required to study the multitude of interactions possible among advanced aircraft, missiles, and electronic devices with each other and with human elements in the nation's most extensive man-machine-computer system.



THE ELEMENT OF FREEDOM

To qualify, substantial prior experience with air-to-air or ground-to-air missiles systems is required together with demonstrated aptitude in the field of system planning. Call collect or write for more information.

System Development Division

The Rand Corporation

2400 Colorado Ave., Santa Monica, Calif. GRanite 8-8293, Extension 53 or 54

11-7

LITHIUM

HIGH ENERGY

fuel for thought

THE fuel propellant of the future may prove to be an inorganic material, with metallic properties, capable of releasing tremendous heat burning capacity. Such an inorganometallic will likely contain a compound of *lithium*. For *lithium* offers uniquely valuable properties . . . properties that aid in contributing an unusually high power-to-weight ratio so necessary for military missiles and rockets.

Lithium, for example, combines low density with high heat of combustion to give a much sought after ratio of extraordinary chemical energy per unit of weight. On this score alone it proves of inestimable value.

Will these properties improve your product?

. . . low density
. . . high heat capacity
. . . high heat of fusion
. . . chemically reactive
. . . low melting point
. . . high flash point
. . . easily cut with a knife
. . . ductile, can be extruded and rolled
. . . readily melted or cast
. . . lighter than magnesium or aluminum
. . . can be dispersed in suitable media

Consult our PR&D department on your use-research problems. Up-to-date Product Data Sheets plus laboratory quantities of lithium metal, metal dispersions, metal derivatives and salts are yours for the asking.

. . . trends ahead in industrial applications for lithium

LITHIUM CORPORATION OF AMERICA, INC.
2610 RAND TOWER, MINNEAPOLIS 2, MINN.

member of...

AMERICAN LITHIUM INSTITUTE, INC.

PROCESSORS OF LITHIUM METAL • METAL DISPERSIONS
METAL DERIVATIVES: Amide • Hydride
SALTS: Bromide • Carbonate • Chloride • Hydroxide • Nitrate
SPECIAL COMPOUNDS: Aluminate • Borate • Borosilicate • Cobaltite • Manganite Molybdate • Silicate • Titanate • Zirconate • Zirconium Silicate

BRANCH SALES OFFICES: New York • Chicago • Bessemer City, N. C.
MINES: Keystone, Custer, Hill City, South Dakota • Bessemer City, N. C. Cat Lake, Manitoba • Amos Area, Quebec
PLANTS: St. Louis Park, Minnesota • Bessemer City, N. C.
RESEARCH LABORATORY: St. Louis Park, Minnesota

Geodesy Comes of Age

(CONTINUED FROM PAGE 73)

radius of the equator.

This method also can be applied to the moon. In fact, when Isaac Newton first proposed the law of gravity, he tested it by comparing the observed radius of the earth with the one calculated in this way. At first, the results did not agree, and Newton then put the thing away. Later, Picard obtained an improved radius of the earth, and Newton, on hearing of it, perceived that it was of the right size to produce agreement. He was so badly shaken up, however, that a friend had to complete the computations for him. Unfortunately the method involves a small correction term depending on the mass of the moon, and this is not sufficiently well known to permit precise application of the method in our times.

If the satellite is at a height sufficient to suppress the effects of atmospheric drag, it can be expected that the chief source of irregularity in its motion will be the roughnesses of the earth's gravitational field. These are called anomalies if they are in the vertical direction, and deviations of the vertical if they are in the horizontal direction. For convenience here, let us call them all anomalies.

The rms value of the gravity anomalies at the surface of the earth is about 25 milligals, which means 0.25 mm/sec/sec. At the height of the satellite, there is a certain averaging effect, which considerably reduces this. In addition, the motion of the satellite itself is so rapid that it tends to average the effects of many anomalies. In consequence, the important quantity is the average value of the anomalies over rather large areas. According to Jeffreys ("The Earth," 3rd edit., Cambridge University Press, 1952, p. 178) the mean squared value over 30 deg squares is 150 (milligals)^2, which seems to mean rms values of 12 milligals. The satellite will traverse 30 deg in about 480 sec, and will thus receive an impulse which will change the velocity by about 50 mm/sec.

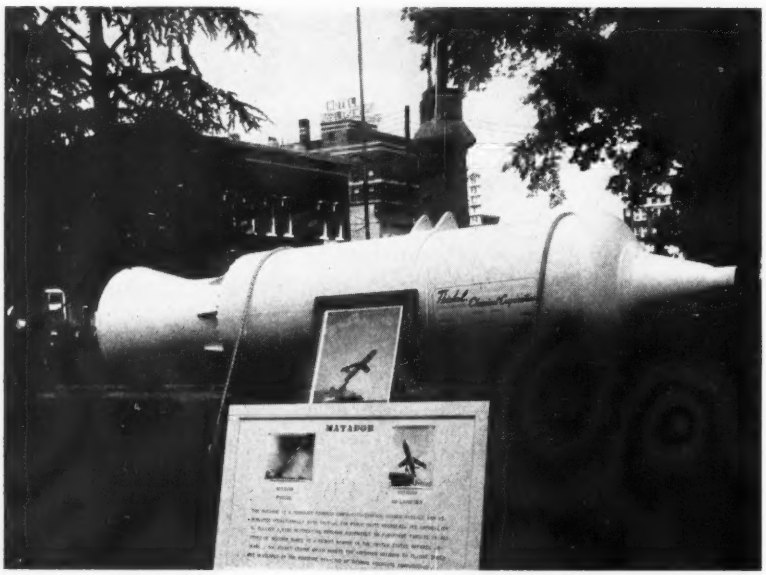
Acting alone, one such impulse would lead, after one day, to a change of position of about 5000 meters, provided that it was in the direction along the path. If it were across the path, it would lead to periodic changes in position with a period equal to that of the satellite, and an amplitude of a few tens of meters. Since many such impulses will occur in each revolution, and since there will be about 16 revolutions per day, it is to be expected that the satellite will be several hundred meters off the path predicted on the basis of a smooth ellipsoid.

Will Be of High Interest

The disentangling of this problem will therefore be of high interest not only to geodesists, but also to those whose job it is to furnish reasonably accurate ephemerides. The observations which will be most useful for this purpose will be, curiously enough, not the optical observations, despite their high precision, but the radio observations, because of their greater number, and above all, because their continuity will protect the theorist from attributing false periodicities to the perturbations which he will find.

In sum, therefore, the satellite can be expected to give us:

1. A truly three-dimensional approach to the problem of large-area surveys.
2. A new method of measuring intercontinental distances.
3. A new method of measuring the figure of the earth.
4. A new approach to the large-scale irregularities of the earth's gravitational field.



No Nickels Needed

"Parked" in downtown Huntsville, Ala., the Dart (top) was part of a large Armed Forces Day missile display that also included Honest John, Little John, Nike-Ajax, Nike-Hercules, Lacrosse and Redstone.

The exhibit attracted visitors from all over Alabama, as well as Georgia, Tennessee and Mississippi, and provided the public with its first "in person" view of the Nike-Hercules and the new Thiokol booster (below) for the Martin Matador B.

breaking
the
problem barrier
...at
Sundstrand-Denver

An organization with a proven record of meeting deadlines, Sundstrand-Denver offers total capabilities from problem statement through product manufacture . . . completely controlled within one plant. Large enough to provide capable, experienced engineering; comprehensive research and testing; prototype manufacture plus low cost quantity production of precision units . . . Sundstrand-Denver is still small enough to maintain exacting control and coordination to expedite on-time delivery of quality products.

Hydro-mechanical equipment for aircraft, missiles, nuclear reactors, rocket and turbine engines. Pumps for Cryogenic fluids and fuels, specialized valves, controls, and actuators.

SUNDSTRAND

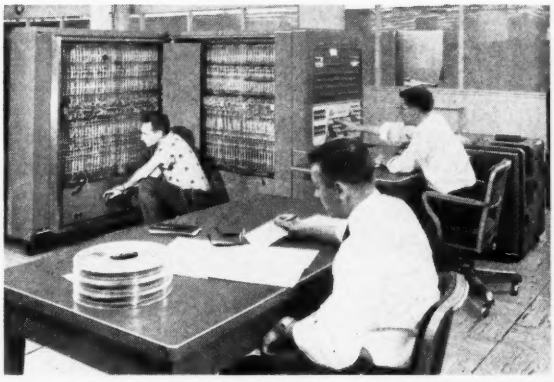
SUNDSTRAND - DENVER

DENVER, COLORADO

A DIVISION OF SUNDSTRAND MACHINE TOOL COMPANY

Plant of the Year Award Winner 1957

Roll Out the Data



Technician (above) checks oscillograms while engineers (right) operate main console of IBM 704, and (above right) work the intercom and switching system consoles at General Electric's new processing computation center in Philadelphia. Part of the company's missile and ordnance department, the center will be used for processing data from missile flight tests, tests of missile environments and components, and for scientific computations needed for advanced studies. Prime service for the facility will be in nose cone development work for the AF ballistic missile program.

THE SKY IS no longer THE LIMIT . . .
The success of astronautical explorations this year will depend largely on exacting product perfection as we probe into the barriers of the unknown. PACIFIC meets the challenge of thoroughness with a complete line of positive tested valves for the missile industry. Figure No. 8550LOX was developed for a broad field of low temperature transfer and storage applications and incorporates economy with dependability. These corrosive resistant valves feature a Kel-F guide and expansion chamber which prevents packing from freezing. Y-Globe Valves with service pressures ranging from 150 lbs. to 2500 lbs. offer a flexibility of service applications.
Whatever YOUR requirements, PACIFIC'S engineers will give you practical recommendations for results you desire. For information write:
PACIFIC VALVES, INC.
3201 Walnut Avenue • Long Beach, California
Figure No. 8550LOX

(CONTINUED FROM PAGE 49)

excitation of molecules and of fragments at high temperatures, followed by separation and cooling in a rapidly expanding jet, and subsequent concentration and freezing out in bulk at very low temperatures.

2. Dissociation and excitation in an electric discharge and subsequent treatment as in No. 1.

3. Dissociation and excitation in a chemical reaction and subsequent procedure as in No. 1.

4. Photodissociation and excitation, using either energetic light quanta (ultraviolet light, x, or gamma rays) or energetic corpuscles.

5. Nuclear transformation, perhaps accomplished most conveniently through the use of slow neutrons. Considerable fluxes are now available, amounting to 10^{14} slow neutrons per cm^2 and second. Impinging on lithium hydride, for example, neutrons will produce (exothermally) the reactions $Li^7(n, \gamma)\ Li^8$, followed by $Li^8(\beta^-) \rightarrow Be^8$ and $Be^8 \rightarrow 2He^4$. The final result may thus be metastable HeH or HeLi, trapped within the LiH crystals in considerable concentrations. Higher concentrations can subsequently be achieved by various methods. Many similar transformations of stable crystals into metastable assemblies by neutron nuclear reactions are possible. Their properties must be explored for purposes of producing high energy propellants stable at low temperatures.

The present author, for the past thirty years, has used a special calcite crystal in his yearly freshman demonstration lectures to illustrate a phenomenon basic to fragment chemistry and metachemistry. This crystal, when irradiated with x-rays or with fast electrons at liquid air temperature, remains nonluminescent. On warming up, the frozen-in radicals and metastable excited states begin to react and the crystal emits part of the trapped energy as intense orange light.

Analogous experiments can be made with many crystals, as well as with plastics, glasses and egg shells. The photographs on the cover and on page 46 show the light emitted from lucite. These substances were irradiated with the gamma rays of cobalt 60 at liquid air temperature. On warming up, lucite emits blue light, Pyrex glass pink light and polyethylene intense green-blue light. All of these substances, after being irradiated at liquid air temperature, remained nonluminous for three days or longer when held at liquid air temperature. On being warmed up subsequently to about − 100 C, the light which they emitted was as intense as that emitted by the substances on being warmed up immediately after irradiation with cobalt 60, except in the case of lucite, which seemed to have lost some of its activity.*

Although observations on thermoluminescence have been made a long time ago, it is rather amazing that only recently have investigators become aware of the possibility of frozen radicals and metastable excited states as propellants (F. Zwicky, *Chemical and Engineering News*, vol. 28, 1950, pp. 156–158), and that there is no sound reason why in some cases temporarily stable concentrations up to 100 per cent should not be achieved in the near future.

Three possibilities of nuclear energy for propulsion naturally present themselves: 1. Nuclear fission; 2. use of naturally radioactive substances; and 3. nuclear fusion. A good deal has been written about putting nuclear reactors activated by fissionable materials into the service of propulsion. Less has been said about the use of suitable radioactive isotopes. As an example, we may consider cobalt 60, which emits two gamma rays and a beta ray, with a total average energy of 2.6 Mev per disintegration, and which has a half life of 5.3 years. As a result of this decay, 4 gram cal are liberated per second and per gram of Co^{60}, corresponding to a few per thousand of *total* energy generated by 1 gram of the best conventional propellant combination.

If we therefore succeed in transfer-

New Matador

TM-61C, newest version of the Air Force's Matador, now operational, is readied for launching. The "C," also made by Martin, is said to have an improved guidance system, highly resistant to electronic countermeasures.

* I am indebted to my associates at Aerojet General Corp., George Moe, E. I. Hormats and Lillian H. Baum, for having executed at my suggestion the experiments which led to these photographs.

ring the energy available from Co^{60}, which is being carried along by our vehicles, to the air flowing through an aeroduct (ramjet), an aeropulse or an aeroresonator (buzz-bomb engine), enormous specific impulses come within our grasp. A great variety of such systems is possible, since many radioactive substances are available. Sc^{46} and Na^{24}, for instance, liberate respectively 96 and 56000 gram cal per second and per gram of Sc^{46} or Na^{24}.

Opens Exciting Perspectives

The use of nuclear fusion naturally opens up the most exciting perspectives. Since only a limited number of means are known today of how to ignite nuclear fusion, we must obviously first search for ways of doing so in bodies of fusable matter of arbitrary size. The prediction is here ventured that many methods will be found to achieve this goal, without the use of any fissionable material whatsoever. I suspect a few dozen scientists today harbor promising ideas of how fusion can be ignited in *all* solids or liquids consisting of any of the lighter elements.

Assuming that the ignition of all fusable materials will ultimately be achieved by convenient means, the following modes of propulsion delineate themselves:

1. Nuclearly fusable material may be carried by the rocket vehicle to be fused and ejected at suitable speeds for the production of propulsive power.

2. As long as the rocket vehicles considered travel in a material medium such as the solid earth, a body of water, air, or the tenuous gases of the outer atmosphere, of interplanetary and of interstellar space, this material can be conducted through the propulsive powerplant, within which it may be nuclearly fused and subsequently ejected to the rear at velocities greater than the forward speed of the vehicle.

3. Another jet engine propellant combination, yielding a practically infinite value for the specific impulse, is the interplanetary aeroduct (*Journal of American Rocket Society*, vol. 84, March 1951, pp. 13–20), traveling through the outer regions of the atmosphere of the earth and of other bodies of the solar system. This type of aeroduct or ramjet derives its propulsive power from scooping up the freely available ions and electrons, as well as radicals like, O, N and others, which, on recombination within the duct, liberate the energy necessary to produce exhaust velocities superior to the forward velocity of the vehicle.

4. The rocket vehicle may be a natural body, such as an asteroid, moon, planet or the sun itself. These, for purposes of interplanetary or of interstellar travel, as well as for the reconstruction of the planetary system (*Observatory*, vol. 68, 1948, pp. 121–143) may be maneuvered through the ignition on their surfaces of directed nuclear fusion jets, using their own matter as propellant. By accelerating the sun to about 1000 km/sec with nuclear fusion jets, mankind might attempt to travel to one of the nearest stars, such as Alpha Centauri within the next thousand years.

Use of Cold Reactors

5. Returning to nuclear fission, one must consider not only hot reactors, as at present, but also cold reactors. The latter do not produce heat directly, but generate radicals and excited states in very cold gases or liquids which are being pumped through them, and which, by carrying frozen radicals and metastable states with them, issue from the reactors as

"MONOBALL"®
Self-Aligning Bearings

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Dept. AST-57.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

American Rocket Society
Northwestern University

Second Biennial Gas Dynamics Symposium

Transport Properties In Gases

All prospective registrants are urged to complete this form and detach and return it before August 8 to **Gas Dynamics Symposium, Department of Mechanical Engineering, Northwestern Technological Institute, Evanston, Ill.** Early mail registrants will be assured of housing.

I plan to attend the Gas Dynamics Symposium, Aug. 26–28, 1957.

Name.....

Affiliation.....

Address.....

I expect to arrive on Aug....., 1957, at.....a.m./p.m.

I expect to leave on Aug....., 1957, at.....a.m./p.m.

I live within commuting distance.....

I request University housing for.....(not for families) starting with the night of Aug....., 1957.

I will arrange my own accommodation.....

I shall be accompanied by family.....

I have.....children

Age of children.....

I expect to attend the symposium banquet. Please make ..... reservations.

powerful propellants.

In association with the large scale problems described, auxiliary problems present themselves, the study of which leads to developments which are often even stranger than those relating to the main projects. As a typical example, I can mention here some thoughts which have their origin in the author's attempts to produce fast self-luminous artificial meteors (*Engineering and Science*, California Institute of Technology, vol. 16, no. 4, 1953) capable of escaping from the earth. Three developments issued from this work:

1. The production of *coruscators* or *coruscatives*, or *heat explosives*. These consist of highly compressed slugs of two or more solid reagents which, on proper ignition, explosively liberate heat and light without flying apart, since the reaction products are all solid or liquid.

2. Using shaped charges to eject the artificial meteors at enormous speeds, the question arises as to why it has not been possible to launch masses of arbitrary size with kinetic energies equal to the thermodynamically nearly ideal fractions of the energy liberated by the propellants used. A detailed inquiry into the shortcomings of guns and of rockets led to a morphological survey of all possible launching devices, which disclosed the amazing fact that, in the whole history of guns and of rockets, some simple fundamental principles have been overlooked. On the basis of these principles, it is possible to construct several novel types of propulsion devices which are capable of accelerating large projectiles with high thermopropulsive efficiency to speeds quite unobtainable today.

Suggest Idea of 'Magic Carpet'

3. Closing the circle back to ancient times, humanity's childhood dream of the magic carpet reemerges. The realization of this dream does not now seem utterly impossible when we remember the successes achieved during the past few decades with the production of exceedingly strong, thin, single crystals. These results suggest the idea of a "spongy" carpet of tiny closed cells, filled with vacuum, hydrogen or helium, the lamella-like walls of the cells being so strong and light that the whole solid carpet is lighter than air. The lifting power of the carpet can be managed by different degrees of elastic compression of its spongy metallic substance.

With this thought, I get away from the roar of big rocket motors, roam in some quiet and distant parts of the earth's atmosphere, and leave the reader to his own fantasies.

Unique opportunities for production engineers

at Honeywell Aero!

Honeywell Aero offers you a variety of exciting production engineering projects in the field of aeronautical controls—projects such as automatic control systems and components for more than 15 of the most advanced Guided Missiles, Ballistic Missiles and Rockets; plus Automatic Flight Control Systems for the F-100, F-101, CF-105 and B-66; and Fuel Measurement Systems for the T-37, XFY-1 Pogo, P6M Seamaster, C-130, Boeing 707, Douglas DC-7, Lockheed Electra, F11F and F-106.

Engineering personnel at Honeywell Aero has more than tripled since 1951. Honeywell sales have increased 600% in the last 10 years. Growth like this promises a future full of opportunities for you.

Here is a partial list of positions now open in Minneapolis

Bellows Specialist: Physics or M.E. Degree, 3 years' experience in high vacuum field.

Production Engineer: 2 years' experience on electromechanical devices, fine pitch gearing, motors and precision parts.

Production Engineer: 2 years' production processing on amplifiers, transistor units and servo mechanisms.

Senior Gyro Engineer: Engineering degree with 5 years' related production experience. Must have ability to lead program to produce new gyro or inertial platform designs.

Senior Electronic Engineer: E.E. degree with 5 years' related electronics production experience. To lead electronic production program.

Production Engineer: B.S.M.E. or equivalent experience. 3 years' experience in processing electromechanical devices.

Production Engineer: B.S.E.E. or Physics degree. 3 years' experience in processing electronic devices. Magnetic amplifier experience preferred.

Production Engineer: B.S.M.E., B.S.I.E. or B.S.E.E. 3 years' experience in processing electromechanical assemblies.

WRITE TODAY!

If you are interested in any of the positions above, or want to learn more about other outstanding opportunities for Production, Research or Design Engineers at Honeywell Aero, send a brief résumé of your education and experience to Bruce D Wood, Technical Director, Dept. TA41A, Minneapolis-Honeywell, Aero Division, 1433 Stinson Blvd., Minneapolis 13, Minnesota.

Honeywell

H Aeronautical Division

High Temperature Flight

(CONTINUED FROM PAGE 53)

temperatures depicted in the chart show that no single temperature can be arbitrarily set as the beginning of the high temperature problem. Rather, the combination of material characteristics and operating environments typical of aircraft and missiles has resulted in a spectrum of high temperature problems.

Propulsion technology has generally been the pacesetter for aeronautical progress. The consistent and sometimes spectacular advances in speed, range and altitude of flight vehicles reflect the advent of powerplants with continually increasing thrust-to-weight ratios. This progress is also the reason why the airframe designer now finds himself in the middle of the aerodynamic heating problem. Propulsion system temperatures have always been a limitation to the powerplant designer and a challenge to the materials engineer.

The propulsion system table on page 53 is divided into four categories, of which the chemical reaction category represents the class of jet propulsion systems generally in current use. The heat transfer category covers rocket propulsion systems in which heat obtained from an external source is transferred to a light gas, which then provides thrust by discharging through a nozzle in a manner similar to combustion-type rockets. Heat transfer rockets potentially offer higher specific impulses than can be obtained in chemical reaction rockets because the low molecular weights of gases such as hydrogen can be exploited advantageously. Ion acceleration and photon rockets represent new types of interest because of their promise for space flight applications.

Service Conditions Are Severe

Temperatures and heat fluxes in the combustors and throats of solid and liquid propellant rocket engines represent as severe a combination of thermal service conditions as are likely to be encountered in the aeronautical engineering field. Erosion of the nozzle throat area is also severe because of the high gas pressures and gas velocities. Sonic velocities in the nozzle throat can reach values as high as 5000 fps. Regenerative cooling of the combustor and nozzle is the present means whereby material temperatures in the combustor and nozzle throat of liquid propellant rockets are maintained at a reasonable value, and this technique will continue to be required in the future. Use of high energy liquid propellants or free-radical fuels in an effort to improve engine performance will impose severe demands upon combustor materials, and could ultimately require the use of a more effective means of cooling than the regenerative method.

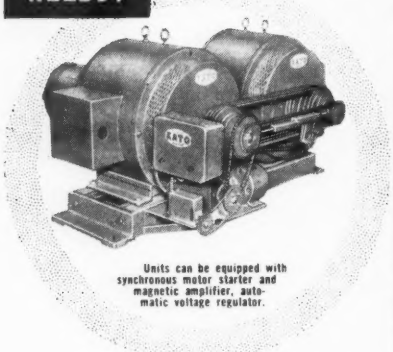
Equipment associated with liquid propellant rocket engines, such as pumps and controls, presents its own temperature problems. Where liquid oxygen is to be handled, the problem is one of low temperatures, ranging down to −297 F. Electronic and hydraulic control system components adjacent to the combustor can reach temperatures of several hundred degrees, and hence present problems as far as fluids and insulation are concerned.

Rockets utilizing the heat transfer principle represent an immature art at the present time. Problems in containing high pressure, high temperature gases will be similar to those encountered in combustion rockets. Also, erosion conditions with respect to heat exchangers can be severe. With plasma jets, a need will probably exist to cool the electrodes of the high intensity arc in which the gases will be heated and ionized.

PRECISE CURRENT for your TESTING NEEDS!

VARIABLE FREQUENCY FULLY AUTOMATIC MOTOR GENERATOR SETS ADJUST 360 TO 400 CPS.

Generator mounted controls include reset buttons, limit switch. Motor and generator remain stationary. Vari-drive pulley adjustment controlled by small motor. Remote control panels available.



Units can be equipped with synchronous motor starter and magnetic amplifier, automatic voltage regulator.

KATO 400 CYCLE MOTOR GENERATOR SETS NOW UP TO 250 KW!

KATO MOTOR GENERATOR SETS are available in frequencies, speeds and sizes for every specialized use . . . operating high cycle tools, testing components and electronic equipment

INPUT 60 CYCLES

OUTPUT 400 CYCLES

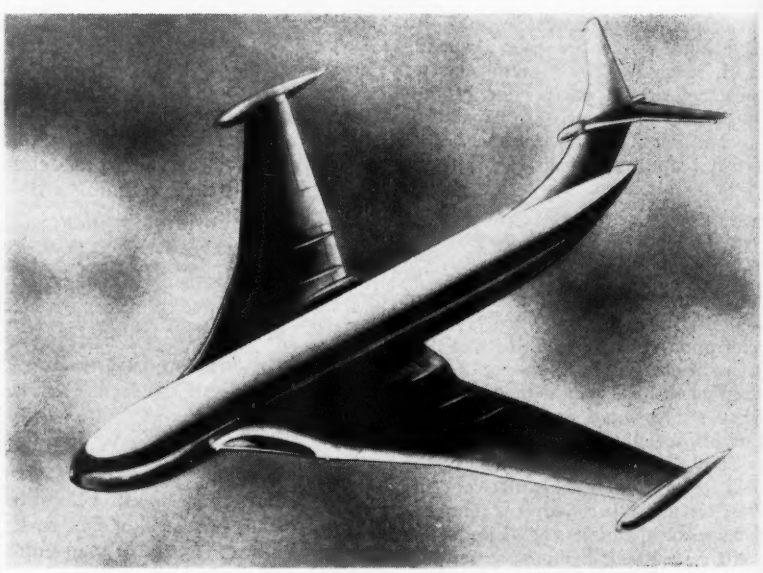
WRITE FOR NEW FOLDER!

Builders of Fine Electrical Machinery Since 1928

KATO Engineering Company

1499 FIRST AVENUE, MANKATO, MINN.

600-mph Handley Page Jetliner



Drawing of proposed Handley Page turbojet airliner.

A passenger version of the Victor turbojet strategic bomber has been announced by Handley Page Ltd. of England. Powered by four Rolls-Royce Conway engines, the ship, said to be capable of cruising at over 600 mph, is expected to enter service in 1961, according to the company.

A long-range version would be capable of carrying 122 passengers from London to New York in 6 hr 21 min, while short-range versions are planned to carry 172 passengers. All versions will operate from existing runways.

on guard . . . the NIKE HERCULES

To guard our cities and other vital areas the Army's new Nike is more powerful than ever before.

Designated Nike Hercules, the ground-to-air missile maneuvers with pin-point accuracy at extremely high altitudes to intercept today's most advanced aircraft.

The range and other details of the Nike Hercules are secret. But to propel the lethal new Nike at supersonic speed to its target, Army Ordnance and Douglas Aircraft Co. chose an entirely new power plant for the missile proper— a solid propellant rocket system developed by Thiokol Chemical Corporation, one of the leaders in solid propellant engines.

Thiokol®

CHEMICAL CORPORATION

TRENTON, N. J. • ELKTON, MD. • HUNTSVILLE, ALA.
MOSS POINT, MISS. • MARSHALL, TEXAS • BRIGHAM CITY, UTAH

® Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers and other chemical products

Ion acceleration and photon rockets represent concepts which are essentially still in the theoretical stage. The high temperature problems associated with the photon rocket, as noted, are beyond the capabilities of current technology. Temperature problems in ion rockets are not yet clearly defined, but probably will be most severe in the nuclear power reactor. Complicated by strong radiation and electric fields, the problems of the ion rocket are likely to strain the state of the art in numerous fields, including materials.

Aerodynamic Heating

Aerodynamic heating is the area of high temperature technology currently of most concern to aeronautical engineers. Progress in understanding the gas dynamics of supersonic and hypersonic boundary layers, plus the knowledge gained from preliminary design studies of various types of vehicle concepts, have brought the essential facts of the problem into reasonably good focus. But the phenomenon of aerodynamic heating is still not completely understood.

The illustration on page 51 demonstrates the aerodynamic heating problem in terms of four types of high speed flight vehicles. Each represents a particular phase of the problem.

• The air-breathing-engine-powered, cruise-type missile is a logical extension of present long-range manned or unmanned aircraft. At altitudes of 60,000 ft or better, high flight speeds can be maintained for long periods with reasonable fuel consumption. Also, the maximum heat transfer rates to the air frame, because of aerodynamic heating at such altitudes, are less than 2 Btu/ft² sec—not much greater than those encountered by a transonic fighter flying at maximum speed at low altitudes. This comparison shows the important effect of reduced air density on heat transfer rates, since rates of over 50 Btu/ft² sec could occur for Mach 3 flight at low altitudes.

But while the cruise missile will encounter relatively low heat transfer rates, the long duration of flight will eventually cause the temperature of portions of the airframe, assuming no cooling or use of insulation, to approach the stagnation temperature of air at Mach 3, which is about 600 F. It is this ultimate structural temperature which represents the problem to the cruise missile airframe designer.

At temperatures of about 600 F, lightweight structural materials such as aluminum and magnesium decrease drastically in strength. This means a heavier structure must be provided for sustained Mach 3 operation than for lower temperature flight conditions. It also means that, in addition to all of the structural and materials criteria previously considered, the variation in material properties with temperature must now be taken into account. This suggests the use of other materials, such as titanium and steel, to obtain the lightest weight structure for flight at the new temperature level.

Structural materials per se present no immediate temperature limit to the cruise missile designer, since many which are available are usable at temperatures substantially above 600 F. Achieving an optimum structure design has become a time-consuming effort, however, because of the need to properly account for all the materials and structural combinations at the designers' disposal.

• High speed air defense missiles represent an aerodynamic heating problem of a highly transient nature. With the possibility of high supersonic Mach number flight in the lower atmosphere, aerodynamic heating rates of up to 10 Btu/ft² sec could be encountered. However, total flight time will probably be small, say less than 5 min. Therefore, it is not likely that heat transferred to the missile structure will increase airframe temperature to a level where material properties are adversely affected, except possibly at stagnation regions such as the body nose and leading edges of lifting or control surfaces.

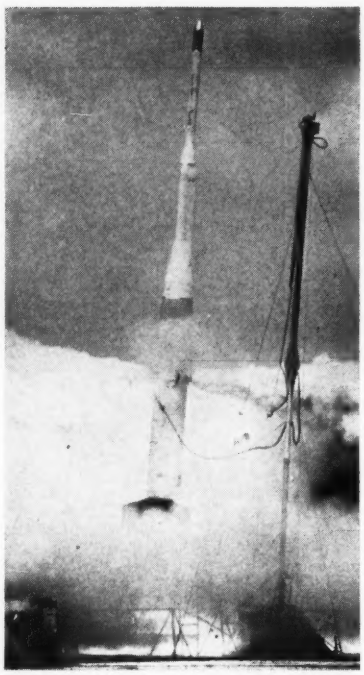
Localized hot spots, plus the rapid transient nature of heating, can, of course, induce large thermal gradients in the airframes of such missiles and thus lead to complex thermal stress patterns that must be allowed for. But standard airframe materials such as aluminum can be used effectively under such transient heating conditions; and, except for radomes [Ed. note: See JET PROPULSION, June, p. 690], no particular material limitations are anticipated for the airframes of short-flight-time aeroballistic missiles.

• The role of heat radiation in aerodynamic heating is demonstrated by the long-range hypersonic glider. This type of vehicle is predicated on the assumption that lift can be obtained in the extreme low density air above altitudes of 100,000 to 150,000 ft. Hence, although the glider may have an initial velocity of Mach 10 or greater, it can decelerate gradually in the thin upper atmosphere so that maximum heating rates may never exceed 10 Btu/ft² sec. Under such flight conditions, and assuming radiation heat transfer laws between the surface and space are not affected by properties of the boundary layer, heat input to the airframe can be radiated outward at the same rate when airframe surface temperatures approach 2500 F.

Metals Hypersonic Gliders

Structural designs for hypersonic gliders can only be speculated on at present. Metals not now commercially available might be developed to function structurally at temperatures approaching 2500 F. But, because of the limited flight time, the possibilities of either using insulation on the outside of the airframe or of cooling the subsurface structure appear more promising. In either case, the design engineer will be confronted with additional degrees of complexity, compared to the two previous vehicle types, in trying to arrive at an optimum airframe structure.

• Re-entry of long-range ballistic missile nose cones can unquestionably be considered the extreme example of the problem of aerodynamic heating. By proper choice of weight and drag



Speed Record for X-17

Lockheed X-17, Air Force re-entry test vehicle, blasts off on its way to new speed record for instrumented vehicles from Patrick AFB, Fla., as spin rockets on side produce stabilizing effect. Speed reached by vehicle was not disclosed.

characteristics of the re-entry body, and if laminar boundary layers can be maintained during the re-entry period, heat inputs at rates as low as about 200 Btu/ft^2 sec may occur. However, if the boundary layer becomes turbulent, these heating rates may increase tenfold or more. In either case, heat inputs are several orders of magnitude greater than those indicated for the vehicles discussed earlier.

Unconventional Approach Used

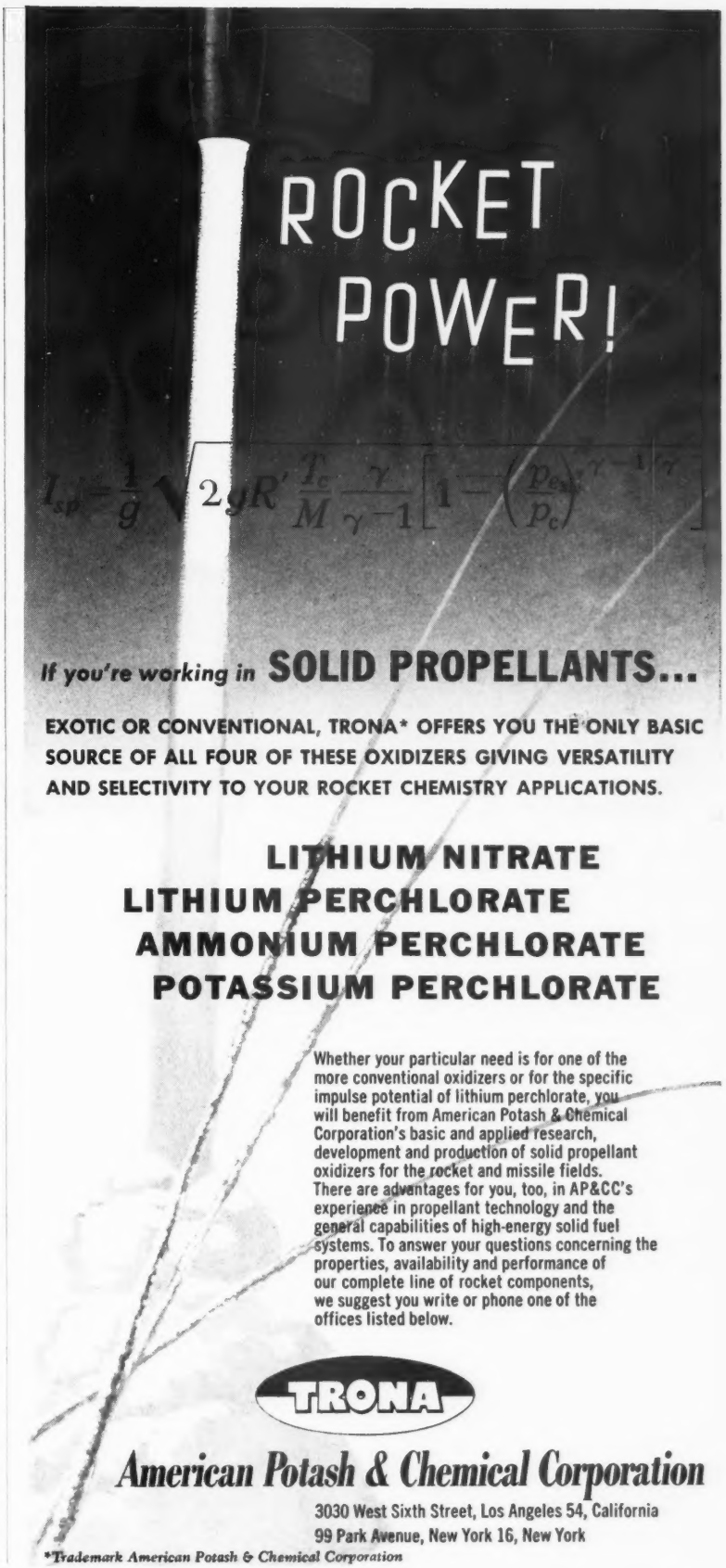
Designing for the intense rates of heating that nose cones must withstand has placed great emphasis on the unconventional approach for obtaining a minimum weight structure. Both thermal capacitance and thermal protection design options have been discussed in the literature. Since the re-entry time of flight can be small, materials that will absorb large quantities of heat, and also conduct the heat away from the heated surface fast enough to prevent melting or undue reduction in strength of the surface, offer the best prospect for thermal capacitance types of structures. Provision will have to be made for the surface protection of such structures if they are made of materials vulnerable to erosion and oxidation.

For the thermal protection type of design, the need will be for materials with low thermal diffusivities, so that surface temperatures will be high enough to melt, vaporize, sublime or ablate away while the subsurface material retains its structural integrity. Special instances of the thermal protection approach would be transpiration cooling and surface combustion reactions.

Common to all design approaches for re-entry nose cones will be the problem of thermal shock. Also, the characteristics of the boundary layer and of air flow over the nose cone must be taken into account. For example, the phenomena of dissociation and ionization of the air in the shock layer and boundary layer and subsequent recombination can influence heat transfer rates significantly. Furthermore, during flight in the extreme outer atmosphere, the potential interaction upon impact between individual air molecules and the molecular structure of the material on the nose cone surface could be important.

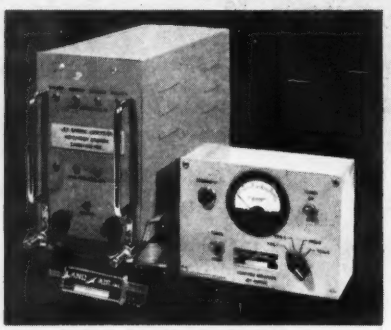
******

Next month, in the second and concluding part of this high temperature report, the authors will cover test concepts and instrumentation, and will discuss materials for high temperature service.


ROCKET POWER!
$I_{sp}=\frac{1}{g}\sqrt{2gR'\frac{T_c}{M}\frac{\gamma}{\gamma-1}\left[1-\left(\frac{p_e}{p_c}\right)^{\gamma-1/\gamma}\right]}$
If you're working in SOLID PROPELLANTS...
EXOTIC OR CONVENTIONAL, TRONA* OFFERS YOU THE ONLY BASIC SOURCE OF ALL FOUR OF THESE OXIDIZERS GIVING VERSATILITY AND SELECTIVITY TO YOUR ROCKET CHEMISTRY APPLICATIONS.
LITHIUM NITRATE
LITHIUM PERCHLORATE
AMMONIUM PERCHLORATE
POTASSIUM PERCHLORATE
Whether your particular need is for one of the more conventional oxidizers or for the specific impulse potential of lithium perchlorate, you will benefit from American Potash & Chemical Corporation's basic and applied research, development and production of solid propellant oxidizers for the rocket and missile fields. There are advantages for you, too, in AP&CC's experience in propellant technology and the general capabilities of high-energy solid fuel systems. To answer your questions concerning the properties, availability and performance of our complete line of rocket components, we suggest you write or phone one of the offices listed below.
TRONA
American Potash & Chemical Corporation
3030 West Sixth Street, Los Angeles 54, California
99 Park Avenue, New York 16, New York
*Trademark American Potash & Chemical Corporation

Missiles and Manned Aircraft Incorporating Research and Development by

LAND-AIR, INC.



The JEVIS

Vibration Indication—
2% Accurate
at 700°F.

Incremental motor pulse
to shaft displacement
1 in 1,000,000
reliable

Investigate **LAND-AIR** *ability as*
Manufacturers—Engineers
Electronics Optics Avionics
X-Ray Electro-Mechanics

LAND-AIR, INC.

7440 W. Wilson **Chicago 31**

Subsidiary of California Eastern Aviation, Inc.

Vanguard Vehicle

(CONTINUED FROM PAGE 63)

will plunge into the sea, 1500 miles from home.

Meanwhile, the solid propellant of the unguided third stage will have ignited after a suitable delay. Spinning around its long axis as it pushes the satellite forward, Stage III will achieve the necessary orbital speed of more than 17,000 mph without gaining any altitude. Thus, 10 min after launching, the satellite will be in orbit.

To completely free the satellite from the third stage, a special separation device was invented. It consists of a completely self-contained unit, Dr. Hagen revealed, "that fits into the socket at the base of the satellite and uses the acceleration characteristics of the third stage as a method of arming and operating."

In the mechanism, a timer waits 26 sec after third-stage acceleration falls off, i.e., after burnout. It then closes circuits to motors which pull hold-down pins and rotate a spring release. The spring imparts a relative velocity of about 3 fps to the satellite, causing it to move away from the burned-out rocket. Like an overly possessive parent, the 7-ft-long third stage vehicle will dog the path of the satellite around the world, a constant reminder, as it were, of the intelligent magnesium sphere's earthly past.

As for the time of the launching, the Defense Department, overseer of the earth satellite program, has said "the vehicle program is progressing in such a way as to indicate a reasonable probability that six fully instrumented launchings can be made before the end of the IGY," reported Richard W. Porter, head of the program's technical panel. "It is understood," he added, "that most of the engineering problems which have been encountered during the last few months have been successfully overcome and that, unless further problems arise which are not anticipated at the present time, there should be no question about achieving the above goal."

Aerojet Liquid Propellant Rocket Launches Bomarc

Aerojet-General Corp. is building the liquid propellant rocket used to launch the Bomarc IM-99 ground-to-air missile, it was announced last month. The missile is launched vertically by the booster and, when it reaches a speed suitable for ramjet operation, the rocket cuts out as twin ramjets take over to provide supersonic cruise flight.

SAFE FLIGHT
SAFE LAUNCHING
WITH CANNON HIGH RELIABILITY PLUGS
Performance of missile launching equipment must not be "hit or miss." Both safe launching and safe flight are required. And right here Cannon's reputation for quality and design experience can help . . . with the most complete and most reliable line available.
Through proper care, analysis, and control, the Cannon organization can furnish missile quality to any AQL desired!
Cannon Missile Connectors have been developed to meet the specialized demands of the guided missile program. They are available in a number of basic shell designs built for heavy duty service, with a variety of different materials available as inserts. More than 22 contact layout arrangements accommodate from 8 to 140 contacts. Coaxial, thermocouple or high-current-capacity contacts are available.
For complete information write for Bulletin on Guided Missile Connectors . . . or contact our factory engineers for assistance in solving your particular problem.
Missile System Connectors . . . For Safety in Flight
Thousands upon thousands of Cannon "standard line" connectors are being used today in missiles of all types. They are noted for the "something extra," the quality, and the reliability Cannon builds into each and every one. More than 27,000 different items to meet your every need. For a brief introductory coverage, write for the New Cannon Plug Guide, Bulletin CPG-3.
D Skid Away Release.
r 50 Size 14 Contacts.
-Solenoid or Manual
. 22 to 140 Contacts.
oaxials Available.
All-purpose
"Unit-plug-in"
Audio
CANNON ELECTRIC
Please Refer to Dept. 504
CANNON PLUGS
Cannon Electric Company, 3208 Humboldt Street, Los Angeles 31, California • Factories in Los Angeles, Salem, Massachusetts, Toronto, Canada, London, England, Melbourne, Australia. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities.

Vanguard Instrument Package

(CONTINUED FROM PAGE 69)

is affected only by variations in switching time, which is comparatively insensitive to operating conditions. The entire telemetering system described here was designed by W. Matthews and his co-workers at NRL.

The Minitrack transmitter is common to all IGY satellite experiments. It serves the dual purposes of transmitting the telemetered signals and providing the tracking source. The crystal controlled oscillator uses a single transistor to produce a 108.0 MC/S CW signal which may be amplitude modulated for telemetering. Including the four antenna rods, the transmitter weighs $1^1/_4$ lb. For three weeks of operation at 50 milliwatts output, 7.5 lb of mercury cell batteries are required.

Requires Sensitive Receiver

Telemetering must be readable under very unfavorable conditions. Low transmitted power and transmission ranges up to several thousand miles require high gain antennas and sensitive receivers at the Minitrack stations. But the sensitivity of the receiving station aggravates the problem of solar and galactic radio noise backgrounds.

In rocket experiments, nose cone temperature may rise to hundreds of degrees C, yet ordinary means of thermal insulation are adequate to protect instrumentation for the few minutes duration of a flight. During powered flight of the launching vehicle, thermal protection of the satellite will be provided by a disposable nose cone. But once the metal sphere is free in space, its temperature will tend to fluctuate with the ratio of time in sunlight to time in darkness.

How can the temperature be controlled so that the satellite will run neither too hot for transistors nor too cold for batteries as it shuttles in and out of sunlight every 90 minutes? Radiative heat transfer is the only active exchange process between the sphere and its environment because convective heating or cooling plays no role in the high vacuum, 300 miles above ground. To avoid overheating, the satellite must be a fairly good infrared radiator. At the same time, it should be visibly bright. Both requirements cannot be simultaneously fulfilled by a polished metal surface. The planned solution to the problem consists of overlaying a bright aluminized surface with a visibly transparent but infrared emissive film of silicon monoxide.

The temperature problem is not limited to radiation balance. Heat is generated internally by the electronics, and conduction takes place to and from the shell via supports and wiring. With the aid of heat switches, it may be possible to keep the temperature excursions of the electronics package within a degree of its equilibrium value. The latter may be fixed by the shell coating technique within a spread of ± 20 deg of a desired value, well within the safe operating range. Components mounted on the surface of the sphere, such as the Lyman Alpha ion chambers, the silicon solar cell, erosion gages and microphones, may be subjected to a maximum temperature of perhaps 150 C during launching and oscillations between perhaps -5 and 30 C during orbital flight.

From the weight distributions indicated above, it is obvious that a major portion of the weight is consumed by batteries, even for an operation period of only three or four weeks. It is not unlikely that solar batteries may be introduced as auxiliary power sources in some of the later IGY satellites. The Signal Engineering Laboratories have already produced a unit with an effective area of 10 cm² which furnishes 3 volts at 20 milliamps. Tests made in combination with miniature silver-cadmium storage cells indicate a life of about 500 charge-discharge cycles.

Environmental Test Program

An essential portion of the satellite instrumentation development is the associated environmental test program. All equipment will operate in high vacuum, and vibration problems may be comparatively more serious than in ordinary research rockets because of the longer duration of powered flight. Prototype models will be tested in vacuum chambers at less than 0.1 micron Hg and at temperatures covering the expected operating range. Each assembled satellite will be subjected to sinusoidal and random vibration tests so designed that survival of the tests will assure at least a 20-to-1 chance of survival in the final launching. Preliminary testing has already revealed modes of failure of transistor and battery components in satellite simulated operation that would not occur in more conventional rocket applications.

The cosmic ray experiment, prepared by the State University of Iowa under James Van Allen's direction, will measure counting rates of a single Geiger counter over segments of the orbit corresponding to different geomagnetic latitudes. Instead of storing merely one peak signal per orbit, it is necessary to store approximately 50 individual time measurements per orbit corresponding to the intervals in which a fixed number of counts are accumulated. These data will be stored by means of a miniaturized magnetic tape recorder and read out via telemetering when the satellite passes over the Minitrack stations.

To Measure Magnetic Field

The earth's magnetic field above the ionosphere will be measured by means of a 3 to 4 lb version of the Varian proton precession magnetometer. J. P. Heppner at NRL expects his experiment to test the hypothesis of extraterrestrial ring currents, to provide data on ionospheric currents, particularly the equatorial jet, and to improve existing knowledge of the earth's main field.

Two experiments are being prepared in the field of meteorology. The purpose of one is to determine the radiation balance of the earth and the atmosphere. Small spheres of differ-

The Bullpup Bows **Made by Martin for the Navy, the new air-to-surface missile made its public debut in the form of this model. The Bullpup is designed for launching from positions outside the effective range of enemy high-volume ground fire.**

ent absorptivities in the visible and infrared will be mounted at the tips of the antenna whips. The temperatures of these spheres will be monitored over the orbit to deduce the net loss or gain of radiant energy in the atmosphere over the latitude belt included by the orbit. Here, as in the cosmic ray experiment, the storage of data over portions of the orbit is necessary. This experiment is being prepared by V. Suomi of the University of Wisconsin.

Will Scan the Landscpae

A second experiment proposed by W. Stroud of the Signal Engineering Laboratories will measure the distribution of cloud cover by scanning the landscape below the satellite with infrared photocells. The spin of the satellite will provide the scanning motion. Orbital data will be stored on magnetic tape and read out rapidly over Minitrack stations. By analog techniques, the view from the satellite can be reconstructed in the form of a map of cloud cover.

Solutions of the basic instrumentation problems involved in these experiments will pave the way for much more elaborate systems in the larger satellites of the future.

AF Scientist Sees Oxygen-Powered Rocket

An experimental vehicle will, within five years, be propelled through the ionosphere on energy given off in the recombination of atomic oxygen that is scooped out of that region, an Air Force scientist has predicted.

Peter H. Wyckoff, of the Geophysics Research Directorate, AF Cambridge Research Center, Cambridge, Mass., envisaged a collapsible craft with a cross section about 1 m square. Boosted into the atomic oxygen-concentrated region 60 miles high, it would suck in fuel onto grid plates covered with a catalyst. The energy released would then expand the other intake gases to provide the necessary thrust. Velocities comparable to the earth satellite, i.e., about 16,000 mph, could be expected, he reported.

Wyckoff told of the craft at a recent meeting of the United States National Committee for the International Geophysical Year. He is a member of the technical panel on rocketry.

Ultraviolet light and other solar energy forms result in the dismembering of molecular oxygen in the ionosphere, imparting high energy to the atomic pieces. Recombination of such pieces, generally called free radicals, is accompanied by sharp release of the extra energy. Research in this area has principally been directed at trying to freeze free radicals on the ground, permitting their controlled reaction at any time from take-off to interplanetary points, rather than only in the ionosphere. The vehicle described by Wyckoff seems to be an intermediate step, however.

A midnight experiment in March 1956 reportedly proved the feasibility of the process. A rocket dumped 18 lb of nitric acid into the oxygen-laden ionosphere. From a pinpoint of light grew a brilliant blue mass, giving off about half a million candlepower at its climax and rivaling a full moon. The gases then dissipated.

The catalyst to be used in Wyckoff's vehicle has been found, he said. Its composition is secret. There remains the unhappy possibility that the catalyst may be susceptible to atmospheric poisons, however, he added.

Such a craft would be limited to an orbit perhaps 50 to 70 miles above the earth, the scientist speculated. But it could have a very long life, thus supplementing and extending data gathered from the satellite.

Engineers for R & D WORK in

Rocket Development

To work with senior project engineers on prototype development and testing of solid propellant rocket propulsion systems. Ability to coordinate efforts and work effectively with others important. B.S. or M.S. in chemistry, chemical or mechanical engineering, with up to five years experience.

Aerodynamics

To work on design and testing problems associated with exterior ballistics of rockets and missiles, and expanding program of other flight systems development. Experience in thermal problems of rocket and missile design and testing helpful. B.S. or M.S. in chemical, aeronautical, or mechanical engineering.

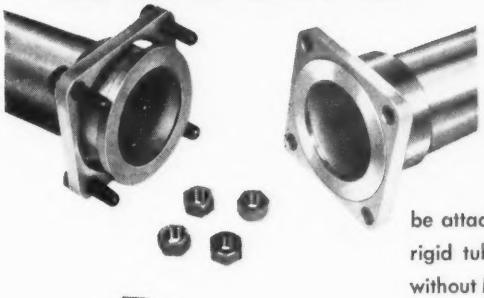
As a research-for-profit operation, ARC has been consistently in the black during its eight years of existence. Company activities increased 50% last year, and we are currently operating at a $2½ million level. In the general growth, advances have been particularly rapid in rocket work. Current rocket projects we can mention include a small auxiliary power rocket for the Project VANGUARD Earth Satellite launching vehicle and our own high-altitude sounding rockets, the Arcon and the Iris.

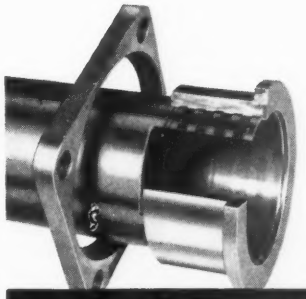
Please send detailed resume of experience, age, salary requirements, and professional references to:

ATLANTIC RESEARCH CORPORATION

Alexandria, Virginia
In the Washington D. C. Metropolitan area

AVICA MECHANICALLY APPLIED TUBE FITTINGS

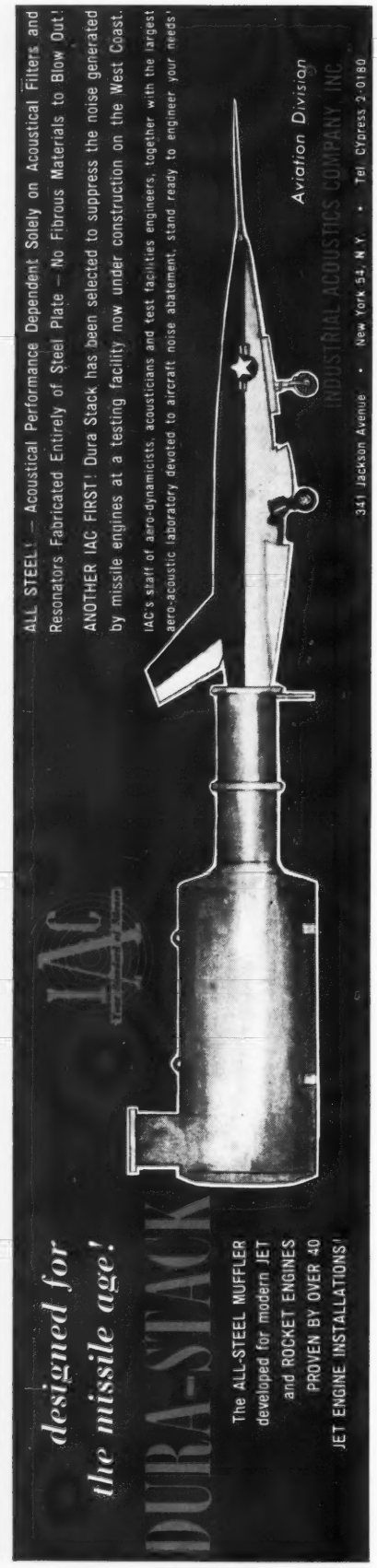




AVICA mechanically applied tube fittings can be attached to any type of metal rigid tubing with hand tools and without *brazing, welding* or *flaring* operations. No heat treating or X-Ray inspections are necessary. AVICA Tube Fittings can be made in a wide range of materials for tubing ranging in sizes from ¾" O.D. to 7" O.D.

For further information write to:

AVICA CORPORATION
P. O. BOX 180, NEWPORT, RHODE ISLAND


designed for the missile age!
DURA-STACK
IAC
The ALL-STEEL MUFFLER developed for modern JET and ROCKET ENGINES PROVEN BY OVER 40 JET ENGINE INSTALLATIONS!
ALL STEEL! — Acoustical Performance Dependent Solely on Acoustical Filters and Resonators Fabricated Entirely of Steel Plate — No Fibrous Materials to Blow Out!
ANOTHER IAC FIRST! Dura Stack has been selected to suppress the noise generated by missile engines at a testing facility now under construction on the West Coast.
IAC's staff of aero-dynamicists, acousticians and test facilities engineers, together with the largest aero-acoustic laboratory devoted to aircraft noise abatement, stand ready to engineer your needs!
Aviation Division
INDUSTRIAL ACOUSTICS COMPANY, INC.
341 Jackson Avenue • New York 54, N.Y. • Tel CYpress 2-0180

Russians Vague on Satellite Plans

Soviet scientists have officially announced they expect to launch the first of a series of earth satellites by the end of 1958 while admitting that the project is still facing "many difficulties."

At a news conference in Moscow called to describe Soviet efforts during the forthcoming International Geophysical Year, elaborate details were given concerning a number of planned Russian IGY projects. However, discussion of the satellite was marked by considerable hedging about its size, physical description and launching site.

The Russians suggested their satellites would be superior to U. S. models but disclaimed any desire to compete with Americans for the first launching while stressing the scientific importance of the project.

Yevgeny Federov, chairman of the Soviet IGY committee for rocket and satellite research, said no definite or even approximate date for launching could be given and turned aside questions as to the launching site as being "of no scientific interest whatsoever." Since several satellites are expected to be launched, he added that no details as to their size or physical description could be given.

Federov disclosed that Soviet satellites would orbit at altitudes ranging from 120 to 300 miles and at a speed of 18,000 mph, and that they would be launched in such a manner that their elliptical orbits would gradually change in flight, permitting them to observe most of the earth's surface. He added that they would remain aloft "for a considerable time."

A close parallel between Soviet and American satellite instrumentation was indicated by Federov's brief description of the experiments planned. The Russians expect to record air density, register and count meteoritic particles, and to determine the energy and composition of cosmic ray particles. He added that, because all the desired instruments could not fit into one satellite, several are planned.

Questioned about the vagueness of his statements, Federov promised that "what interests scientists" about the Soviet project would shortly be made public and expressed the hope that the U. S. would adopt the same attitude.

A few additional details concerning Soviet satellite plans were revealed at a press conference at the headquarters at Uccle, Belgium, of the 64 national scientific committees participating in the IGY, by Marcel Nicolet, IGY general secretary.

Dr. Nicolet said Russian satellites would travel in a polar orbit near but not over the Arctic and Antarctic, taking about an hour and a half to complete the orbit. Holding his hands about 18 in. apart, he said: "This may be the diameter of the satellites."

Russian plans, revealed in a letter from I. P. Bardin, vice-president of the Soviet Academy of Sciences, to Lloyd V. Berkner, a U. S. reporter on rockets and satellites for the IGY, call for use of the satellites in geophysical, physical and astrophysical experiments of various kinds, and for observations of the relativity effect and the shape of the earth.

Dr. Nicolet also gave some details about Soviet plans for IGY rocket launchings. The Russians plan to launch 125 rockets from three different sites, with 70 to be fired at a site in the middle latitudes of the Soviet Union, 25 at the arctic Franz Josef Archipelago and 30 from ships operating near Mirny in the Antarctic. The rockets will be used to measure solar radiation.

Soviet Scientist Predicts Unmanned Moon Rocket Soon

A Soviet scientist predicted last month that his nation would send a radio-guided reconnaissance rocket to the moon in the early 1960's. Writing in the youth paper, *Komsomolskaya Pravda*, U. S. Khlebtsevich, chairman of a Russian technical committee concerned with rocket guidance techniques, went on to say Soviet scientists would establish a permanent manned station on the moon within five or 10 years thereafter.

Seemingly undaunted by the unwillingness of Soviet scientists even to set a date for the launching of their earth satellite (see above), Khlebtsevich predicted further that an unmanned vehicle would go to Mars between 1965 and 1971 and that rockets would also be sent to explore Venus.

He described the moon vehicle as the often-mentioned Russian tankette laboratory, noting that it would require 250 tons of fuel for the flight and would be "absolutely reliable." Reliability would be assured by radio and television guidance, cutting overall costs despite the much heavier weight of the vehicle.

Rockets of this type could be fired, Khlebtsevich declared, without waiting for the construction of large satellite stations. Earth-moon-earth flights, he said, would be commonplace by the end of this century.

Army Acquires Supervisory Control over Aircraft Plant

The Army has acquired supervisory control over an aircraft plant for the first time in its history. The plant is The Martin Co. factory in Orlando, Fla., which produces the Army's Lacrosse missile, and is now under Army "cognizance."

By assuming cognizance, the Army will be the military department responsible for supervising and inspecting production. Until now, only the Navy and Air Force have exercised cognizance over aircraft plants. While largely an administrative step at this time, the move could be important in wartime, when the Army would have first priority in dictating what the plant could produce.

France Building Copter Carrier

The French Navy is building what is reportedly the first specially designed helicopter carrier. Fleet Admiral Henry Nomy, in this country to study modern ship weapons, including guided missiles, revealed recently that the keel for the 10,000-ton carrier, designed to carry 12 turbojet copters of French design and manufacture, has already been laid in Brest, and that the ship would be completed by 1961.

Truax Sees Moon Rocket In Five Years If . . .

The United States will be able to send a payload to the moon and launch a manned satellite within five years after it fires its first intercontinental ballistic missile if the nation's taxpayers would put up the money, AMERICAN ROCKET SOCIETY president Robert C. Truax said recently.

"We will have the know-how and the material, and the whole space program could be ushered in with a contribution of $2 a year from each taxpayer," Truax told a group of reporters at the ARS Semi-Annual Meeting in San Francisco.

"I'll admit I'm optimistic," he added, "but I think the program could be financed with a once-a-year payment by the country's 50 million taxpayers of the amount they would spend for a carton of cigarettes or a bottle of whiskey."

Rocket Shot Marks Opening Of U. S. IGY Program

A Navy Dan rocket firing on July 2 at San Nicolas Island, Calif., an observation post on the ocean firing range of the Navy missile test center at Point Mugu, marked the start of the first major U. S. research project of the International Geophysical Year.

The shot, the first of 14 designed to provide information on how and why radiation during periods of major solar activity disrupts radio communications, was fired by a Naval Research Laboratory team which is working in collaboration with astronomers at the Mt. Wilson Observatory in Pasadena, Calif., and observatories at Boulder, Colo., and Sacramento Park, N. Mex.

The rocket, a combination Deacon rocket and Nike booster which reached an altitude of 80 miles, carried in its nose instruments designed to measure the intensity of solar ultraviolet and x-rays in the ionosphere.

The sun cooperated nicely with the IGY, a major solar flare occurring the day the world scientific investigation got under way.

Bell Acquires Site For Research Center

Bell Aircraft Corp. has announced the acquisition of a 350-acre tract near Pembroke, N. Y., to be used as the site for its new Lawrence D. Bell Research Center. Initial expenditure for the center will be $1 million. The first unit will be a hypersonic wind tunnel, capable of handling the highest speed ranges. This will be followed by a laboratory for heat studies. All services and facilities at the center will be available to other manufacturers.

Occupancy of the company's new $750,000 electronic data processing center at the Bell Wheatfield plant is slated for this month. The center was built as part of the consolidation of the company's Niagara Frontier operations and will handle computing for Bell's technical programs.

1957 'Aviation Facts And Figures' Available

The 1957 edition of "Aviation Facts and Figures," the official publication of the Aircraft Industries Assn. of America, is now available. Priced at $1, the 124-page volume includes chapters on guided missiles, aircraft production and facilities, research and development, military aviation and manpower.

Missile Arming Solenoid tested at 115,000 ft.

A new arming solenoid, qualified to MIL specifications has been tested at altitudes to 115,000 ft. Designed specifically for arming of a missile on a very high performance fighter, the solenoid can be adapted to other applications. The compact unit weighs only 11 oz., has a normal power drain of 0.7 amps and operates at down to 18 volts. At −65° F and 29 vdc power drain is only 1 amp. Operating temperature range is +250° to −65° F.

While specifications required testing to a lesser altitude, the solenoid was tested at 100,000′ and 115,000′. At 100,000′ altitude 700 RMS 60 cycle current was applied between winding and case for more than a minute. There was no corona discharge, arcing or shorting. At 115,000 feet the test was repeated with voltage being increased at a rate of 25 volts/second. At 825 volts a corona appeared suddenly. Apparently based on electron emission there was no sharply defined path of high conductance. Subsequent retesting of the identical unit showed no damage resulted from the 115,000′ test.

For further information on this high altitude solenoid write to:

STRATOS
A DIVISION OF FAIRCHILD
ENGINE AND AIRPLANE CORPORATION

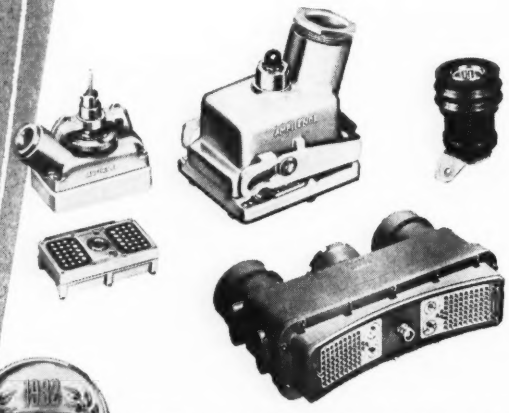
Western Branch: 1800 Rosecrans Ave., Manhattan Beach, California.

AMPHENOL

MISSILE CONNECTORS

The details or the degree of AMPHENOL'S *extensive participation in important missile programs can't be published. It's no secret, however, that missile components must be reliable—or that* AMPHENOL'S *engineering excellence and top product quality have established the highest standards of reliability for connectors and cables in the component industry.*

Your nearby AMPHENOL *sales/engineering representative will be happy to consult with you on your* reliability *requirements—for missiles or for any electronic application.*



AMPHENOL ELECTRONICS CORPORATION
chicago 50, illinois

British Navy Reveals Seaslug Missile Details

The British Navy has revealed some additional details concerning its Seaslug ship-to-air missile. The Seaslug propulsion system consists of a sustainer and four boosters, the latter jettisoned after propelling the missile to supersonic speeds.

It is described as a medium-range weapon designed to engage enemy bombers that evade Fleet fighter defenses at any height at which modern aircraft are capable of operating. First installation will be on the four guided weapon destroyers now on order. The Admiralty noted the missile can be operated and fired from positions within a ship without exposing any personnel.

Olin-Mathieson Expanding High Energy Fuel Facilities

A four-year expansion program centering on the development and production of high energy solid propellants was announced last month by Olin-Mathieson Chemical Corp. New research and development facilities, pilot plants and production facilities will be constructed at the firm's Ordill Works near Marion, Ill.

The program, marking the company's first major effort in solid rocket propellants after 10 years of R&D work, will include the development of new propellants and new production processes. Development and production of gas generators for auxiliary power units on jet engines and missiles will also be expanded. In addition, the company expects to cast double-base rocket propellants and composite propellants at the new facilities.

NSF Offers Fellowships

The National Science Foundation has invited applications for fellowship awards to be made in this calendar year. Closing date for applications is Sept. 3, with approximately 60 awards to be announced Oct. 18.

The fellowships are open to any U. S. citizen who has a baccalaureate degree or its equivalent, has demonstrated ability and special aptitude for science teaching and advanced training, has taught at the collegiate level as a full-time faculty member for not less than three years, and intends to continue teaching.

Application forms may be obtained from the Division of Scientific Personnel and Education, NSF, Washington 25, D. C.

Nickerson Let Off Lightly after Pre-Trial Confab with Army

Col. John C. Nickerson Jr. drew a year's suspension of rank, forfeiture of $1500 in back pay and an official reprimand from an Army court-martial in Huntsville, Ala., for leaking missile secrets, after the Army agreed to drop three major counts of perjury and espionage in return for a guilty plea by the former Army Ballistic Missile Agency liaison officer to 15 minor counts of security laxness.

The Army's action and Nickerson's plea succeeded in its aim of warding off a full-scale review of the nation's entire missile program, although the colonel himself and other witnesses, including Wernher von Braun, Ernst Stuhlinger and Maj. Gen. John B. Medaris, ABMA commander, took the opportunity to claim superiority for Jupiter, the Army version of the intermediate range ballistic missile, over the AF Thor.

Was Nickerson Risk Needless?

The risks Col. John C. Nickerson Jr. took to fight the Wilson long-range missile directive may have been in vain, if reports circulating at the Army Ballistic Missile Agency prove true. Many top ABMA officers feel the controversial directive may soon be modified so as to permit the Army to continue work on intermediate range missiles.

While Secretary Wilson has refused to comment on these reports, authoritative sources say the Defense Dept. was considering changes in the directive even before Nickerson's charges were made.

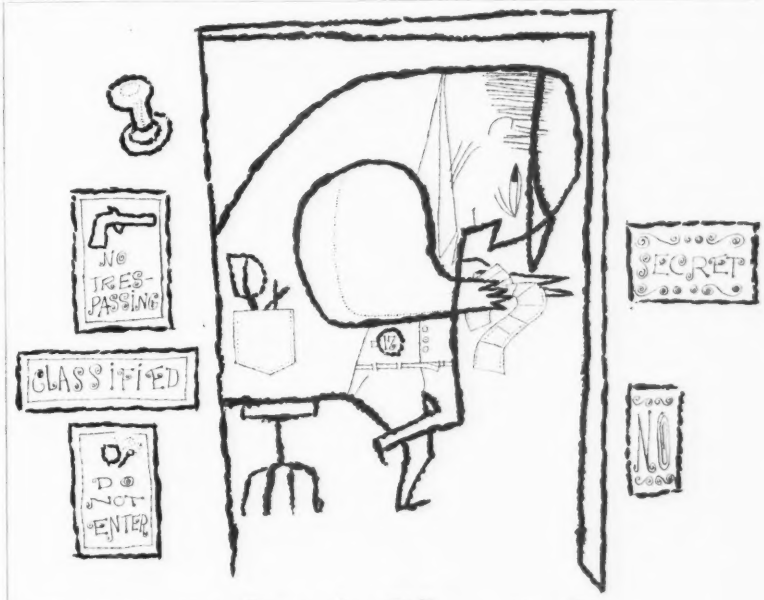
The court-martial arose over Nickerson's release of certain classified information to unauthorized sources in an effort to reverse the decision by Secretary of Defense Charles E. Wilson to assign the IRBM role to the Air Force while directing the Army to restrict itself to 200-mile missiles.

Stuhlinger praised Nickerson, describing him as a man who stuck his own neck out to save the Army's guided missile program from maiming or extinction and crediting him with holding together the ABMA missile team, which was being wooed with lucrative offers from private industry.

Von Braun also praised the colonel as a dedicated soldier who had made great contributions to the ABMA missile team and lashed out at the Army's security policy, claiming it was so strict it actually impeded national security. He noted that the policy had made it impossible for the public to realize how important it was to keep the Army missile team together so it could continue work on Jupiter, and added that Nickerson had sacrificed himself by means of technical violations to inform the public.

Gen. Medaris offered some damaging testimony against the colonel, noting that he had "absolutely and diametrically violated" his instructions not to challenge Wilson's decision, adding: "He does not have any further potential value to the military service."

Nickerson, a career Army officer, said after sentence had been passed by the court-martial board of five generals and five colonels, that he expected to be transferred overseas but would carry on his fight for Army control of long-range missiles by writing books and magazine articles cleared through regular security channels in the future.



Your project film gets custom care at Telefilm

AT TELEFILM, your 16mm project or development motion picture gets *individualized* attention from engineering film *specialists*. The result: release prints of highest technical quality.

YOU GET your order *on time*, too. During our 15 years of film work for leading companies in aircraft, electronics and missile fields, we have developed extremely efficient expediting techniques. If you're outside Los Angeles, use air mail or Air Express to cut transit time. We'll return your prints the same way.

LET TELEFILM show you what a difference *custom* care by *specialists* can make. It costs no more.

TELEFILM
INCORPORATED
6039 Hollywood Boulevard
Hollywood 28, California
Telephone HOllywood 9-7205

- **black-and-white work prints**
- **color release prints**
- **black-and-white release prints**
- **sound recording**
- **complete 16mm services**
- **all facilities under one roof and one responsibility . . . under our constant control**

Talk over your motion picture needs or problems any time with TELEFILM's engineering film specialists. No obligation.

A leading 16mm motion picture technical service since 1938

New Japanese Rocket Undergoes Successful Test

A supersonic rocket that will be used this summer for high altitude sounding by Japanese scientists in connection with the International Geophysical Year was tested successfully in Japan recently. The rocket, of Japanese design and manufacture, is reported to have reached an altitude of $17^1/_2$ miles and Mach 3 in its flight.

Bird of Prey

A new air defense missile system, designated the Hawk, has been successfully developed by the Army to combat low flying aircraft. It is expected to complement the Nike family of missiles whose basic mission is to defend against high flying craft.

The system is versatile and mobile, capable of operating in the continental U. S. air defense complex at fixed installations and in the field with fast moving troops. Transportation by highway is said to require "a minimum of vehicles." It can also be moved by helicopter and airplane. Marine Corps troops will use the system.

The missile is solid propellant fueled, and is approximately 16 ft in length and 14 in. in diam. "Unusually successful" guidance systems are incorporated into the weapon, including "radars of unique design . . . highly effective in detecting and tracking the low flyers in the blind zone of conventional radars."

Site selection actions for Hawk have already been initiated in the New York City and Washington-Baltimore areas. Land required for individual sites is a relatively small 40 acres, the Army reveals, but "positioning of the site is comparatively rigid." Underground storage of the missile for safety and site size reasons is planned.

Raytheon Mfg. Co. is prime contractor for Army Ordnance for development of the Hawk system, with Northrup Aviation the major subcontractor. In addition, Raytheon has the production contract. Research and development missiles are now in production at its Andover, Mass., plant, where pilot production will begin shortly.

NOL Develops Rechargeable Battery for Missile Use

The Naval Ordnance Laboratory last month announced development of a tiny dry-cell battery that can be recharged, stored for long periods and works equally well at subfreezing and extremely high temperatures.

Nicknamed the "Mighty Midget," the battery was developed for use in missiles or underwater units. No bigger than a half-dollar, it is expected, on the basis of NOL tests thus far, to have a useful life of well over 10 years with recharging.

The battery has electrodes of silver and lead, with an electrolytic solution of potassium hydroxide. Unlike the conventional dry-cell unit, it has a reversible electrode chemical system. Thus, on recharging, the lead oxide returns to lead and the silver to silver oxide.

The battery, enclosed in a case about the size of a man's wristwatch, delivers 0.9 volts, compared with the 1.5-volt output of the common dry cell, and has a capacity of 1.5 amp-hr. It can be wired in series or parallel to provide any desired voltage or amperage.

World Aero Sciences Council Organized

Formation of the International Council of the Aeronautical Sciences has been announced by the Institute of the Aeronautical Sciences. The organization, the first of its kind, has been formed specifically to extend international cooperation in all scientific areas pertaining to mechanical flight. The IAS will act as the permanent secretariat of the group and provide the operating staff.

Sixteen delegates attended the organization meeting of the group in Paris and make up the ICAS Provisional Council. Nations represented at the meeting were Canada, France, Germany, Great Britain, Holland, Italy, Spain, Sweden, Switzerland and the United States. U. S. representatives at the meeting were Hugh L. Dryden, director, National Advisory Committee for Aeronautics; S. Paul Johnston, IAS director; and Theodore von Kármán and Frank L. Wattendorf, chairman and director, respectively, of AGARD, NATO.

The first international congress of the ICAS is scheduled for Madrid, Spain, in September 1958. Subsequent congresses will take place in other countries biennially.

Funds toward support of the council are being made available through the IAS by utilization of a substantial donation by Harry F. Guggenheim, and in his honor the ICAS has established the Daniel and Florence Guggenheim International Memorial Lecture, to be presented at each international congress.

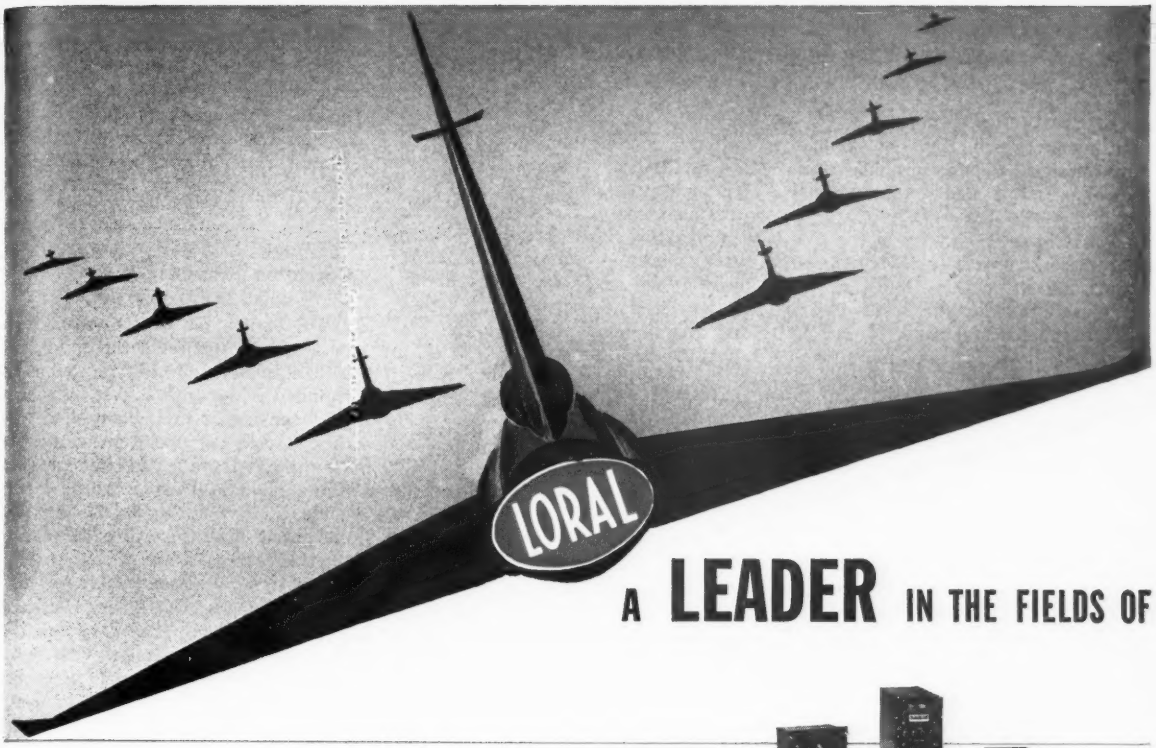
Lockheed Team Seeks To Crack Human Barrier

A team of Lockheed Aircraft Corp. scientists, assisted by 10 specialists from the nation's leading colleges, is setting up a project at the company's Georgia Div. at Marietta to test the endurance of pilots and crew members on extended flights. Such flights could include possible space travel, as well as those in the unlimited range of the potential nuclear-powered airplane.

The Biophysics Branch of the AF Aero Medical Field Laboratory, Wright-Patterson AFB, Ohio, which has already made initial studies of the problem, contracted with Lockheed's Military Operations Research Engineering Div. to investigate the stresses imposed by confining an air crew to a small flight station for an extended period of time.

A full scale mock-up of a small flight station is nearing completion, with tests scheduled to get under way this month. The tests call for confining air crews in the mock-up for periods of 120 hours while the scientists study the effects of keeping a five-man crew in such a small area for so long a period.

Versatile Weapon **Zuni, the Navy's 5-in. high velocity rocket, shown here alone for the first time, has folding fins for neat diagonal packaging in units of four. Approved for fleet operational use by interceptors and attack aircraft, it can serve both as an air-to-air and air-to-ground weapon.**



A **LEADER** IN THE FIELDS OF

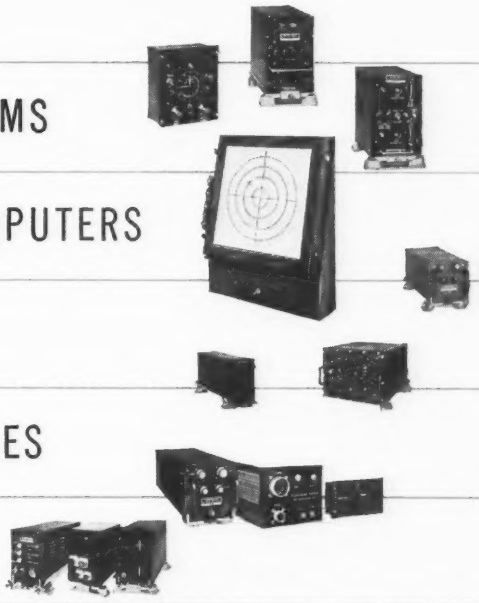
ASW and AEW DISPLAY SYSTEMS

AIRBORNE NAVIGATIONAL COMPUTERS

MILITARY PLOTTERS

ELECTRONIC COUNTERMEASURES

GUIDANCE SYSTEMS



...AND IN OTHER IMPORTANT AREAS

SERVING THE ARMED FORCES AND THEIR
PRIME CONTRACTORS IN THE FIELD OF AVIONICS
IS OUR MOST IMPORTANT BUSINESS!

LORAL ELECTRONICS CORPORATION

NEW YORK 72, NEW YORK

NEW LORAL PLANT, OVER 100,000 SQ FT. OF AIR CONDITIONED WORKING SPACE DEVOTED TO CREATIVE DEVELOPMENT AND PRODUCTION

Toward Improved Missile Communications

(CONTINUED FROM PAGE 55)

emitting at the same frequency a much stronger signal than was originally put in. The result was a net gain in signal strength.

The resonant frequency of the gaseous maser deviates relatively little—about one megacycle—from its primary value, making the device essentially untunable and hence limited in use. This device can be put to fine use, however, as an oscillator of exceptionally high purity. To achieve this, more than enough energy to overcome absorption losses is fed back into the gas at the resonant frequency to cause emission of microwaves of very little frequency variation.

Ranges Over Wide Band

The resonant frequency of a solid state maser happily ranges over a wider band on either side of the primary value, as shown in the table on this page. With a magnetic field, the frequency can be varied over the bandwidth to permit tuning. In fact, one Bell scientist, K. Bowers, believes the magnetic field, and hence the cumbersome magnet necessary to produce it, can be eliminated by propitious use of paramagnetic crystals.

With solids, however, separation of molecules with high energy electrons from those with electrons in the lower state is not feasible. Entropy requires a greater population in the lower state. Using a technique called "adiabatic fast passage," energy at the resonant frequency between states was pumped in, causing the populations to reverse themselves. Then, a small signal causes the high energy electrons to drop back and revert to stable distribution, producing amplification. Major disadvantage of the technique was that the system was excited by pulses, rather than by continuous waves, which permits only the intermittent amplification of a signal.

The three-stage maser, using crystals such as gadolinium ethyl sulphate with electrons at three energy levels, removes the pulse objection. Microwave energy is pumped in continuously at the frequency corresponding to the difference between the highest and lowest states. Signal input resonant to the difference between the highest and intermediate states is then continuously amplified as the electrons drop to the middle energy level. Bandwidth is roughly 100 mc.

Bell's three-stage maser turned out oscillations at the signal frequency of 9000 mc with a power output of about 20 microwatts and an energizing frequency of 17,000 mc. Estimates of the noise level from the device correspond to thermal noise at 5 to 10 K.

Low temperature operation was used so that power saturation of the crystal took place with a reasonable amount of power, Bell physicists say. Also, the difference between energy levels is greater at low temperature. In the device, shown on page 55, both crystal and cavity were immersed in liquid helium at 1.2 K. With such basement temperatures becoming more and more common, the low temperature requirement does not pose too great a problem, although room temperature operation would be more desirable, of course.

Provides 1000 mc Bandwidth

A new device that promises not only to eliminate this drawback but, far more important, provides a bandwidth of 1000 mc has been invented at Bell by H. Suhl and M. T. Weiss. News of the successful operation of the device, based on the magnetic ceramic material called ferrite, was announced last month.

Maser and Ferrite Device Characteristics

Method	Bandwidth (mc)	Tuning Range	Continuous Wave Operation	Low Temperature Need	Noise Level (F minus 1) Value
Beam defocus (NH_3 gas)	$^1/_{100}$	Essentially untunable (1 mc)	Yes	No	$^1/_5$
Adiabatic fast passage (solid)	10	Narrow	No	Yes	$^1/_{50}$ (est.)
Three-level (solid)	100	Wide	Yes	Yes	$^1/_{100}$
Ferrite	1000	Wide	Yes	No	$^1/_{10}$

Ambient temperature operation will be paid for by a higher, but theoretically still quite acceptable, noise level in the ferromagnetic amplifier. And, besides the large bandwidth, the inventors claim it can be designed for use in practically any portion of the microwave spectrum.

Operating Principles Differ

The ferrite device has certain superficial similarities to the solid state spin amplifier. Both types must be supplied power at a higher frequency than the signal to be amplified, but the principles of operation of the two are quite different. "In oversimplified terms," Dr. Suhl explains, the ferrite device "relies on modulation of the real parts of a susceptibility, rather than on reversal of the normal population of the two (electron spin) levels."

Operationally, the ferrite crystal is placed in a microwave cavity that is simultaneously resonant at two signal frequencies, as shown in the schematic drawing on page 55. Microwave power at a frequency equal to the sum of the signal frequencies is pumped into the cavity. Also applied is a d-c magnetic field, properly oriented and of sufficient intensity to cause gyromagnetic resonance in the ferrite sample.

An incoming signal at either of the lower frequencies will cause amplification (or oscillation) at that signal frequency. Another feature of the device is that a signal at one of the lower frequencies can be converted into an amplified output at the other lower frequency.

Circuit analog to this ferrite amplifier would consist of two circuits, shown in the diagram on page 55, connected through a mechanically movable inductance or capacitance $L(t)$. Resonance of the circuits (ω) corresponds to the resonant frequency of the device. Rapid oscillation of the load at a frequency ω, equal to the sum of the two circuit resonances $\omega_1 + \omega_2$, will cause the mechanical energy to be translated into electrical energy. If the energy exceeds circuit losses, oscillations in the circuits at the sum frequency will result. Further, if a signal is fed into one circuit and the energy exceeds circuit losses, the signal will be amplified when taken out of that same circuit at a different point.

In the "ions in solution," or "solion," devices developed by the Defense Research Lab of the University of Texas and NOL scientists, several common electrochemical phenomena are combined to give a new technology for very low power detection. Among

the many units that can be made are transducers and mathematical converters for inertial guidance systems in missiles.

The electrochemical effects on which the devices are based include the diffusion current that passes between platinum electrodes, commonly used to analyze a solution of electrolytically reducible or oxidizable substances; and the increase of current between electrodes with agitation of the solution, the current being a function of the fluid flow between electrodes. Operation of the "solion" family depends on control of this current output function with relation to fluid flow. Linear or logarithmic current output as a function of flow can be obtained by changing the electrode design, the inventors claim.

Main advantage of the new devices lies in their very low power consumption, said to be much less than that required to operate a comparable transistor system. Other features are inherent stability, long life, ease of manufacture and simplicity of operation. Principal disadvantage, one limiting a-c operation is the low frequency range over which they are operable, presently lying between 0 and 200 cps.

A typical flow detector for the unit would use iodine and potassium iodide in water, a completely reversible reduction-oxidation system with no depletion of the unit during the chemical processes. Acceleration of the system, connected simply to a battery and microammeter, will show a current output, varying with accelerations up to 1000 cm/sec^2, between 75 and 260 microamps (at 30 cps). The frequency response of such a system, about the size of a demitasse, is best from 30 cps down to direct current, particularly between 2 and 10 cps.

Changes in velocity or direction could force iodide ions by means of a flexible diaphragm through a detector. This measurable flow could provide quantitative data on a vehicle's course and, in turn, signals to compensate for deviation, according to N. N. Estes, head of the project for NOL. Pressure changes on the cell could likewise be detected.

In the separated detector cell, shown on page 54, flow is from left to right (concentrated to dilute) to produce an electrical signal directly proportional to the magnitude of the flow. For a detector operating linearly, i.e., reducing all the iodine in the fluid reaching the platinum gauze electrode, it can be shown that flow rates as low as 10^{-5} cm^3/sec (assuming an iodine normality of 10^{-1}) can yield currents in the neighborhood of 100 microamps, or about 10 times the no flow current. However, as an accelerometer, the cell would have insufficient detector sensitivity to compete with gyroscopic systems, Estes said.

Finally, a unit to perform various mathematical operations upon the current output of the devices would feature the reverse operation, that is, convert very low power electrical signals into fluid flows. Such a device, called an electro-osmotic cell, can provide, besides amplification, the math computations of products, ratios, derivatives, etc., the inventors say.

IGY Sounds off

(CONTINUED FROM PAGE 65)

Canadian and American, involved in carrying out the operation.

These first two firings at Fort Churchill are only a small part of the world-wide scientific effort that will be carried out during the present 18-month International Geophysical Year. Much of this effort, of course, will have nothing to do with sounding rockets, but a significant portion will.

At Fort Churchill alone, there are 74 more research vehicles waiting to be launched. There are 43 Nike-Cajuns, 21 Aerobee-Hi's, and 10 Aerobees. All will be instrumented for atmospheric research: some will be concerned with pressure, temperature and density 150 miles up in the ionosphere; others, with temperature and winds at somewhat lower altitudes. Still others will be designed for study of such phenomena as cosmic rays, auroral particles and magnetic field, chemical and ion composition, horizons, airglow, water vapor, and magnetic field electron density.

In charge of the different firings will be scientists from the Naval Research Laboratory, the State University of Iowa, the Signal Corp Engineering Laboratory, the University of Michigan, and the Air Force Cambridge Research Center. These men will pour over their results for years, analyzing and correlating them with other data recorded all over the world.

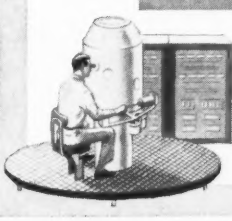
The resultant increment in man's knowledge of the universe is expected to be immense. Less significant, perhaps, but nevertheless important, is the fact that rocket men will learn more about the vehicles they work with. They will undoubtedly improve their techniques, and, most important, they will learn of mistakes to be avoided and modifications to be made in future rocket designs and firings.

ENGINEERS WITH AN EYE TO THE FUTURE— LOOK AHEAD WITH H. A. WAGNER COMPANY

Continuing expansion of H. A. Wagner Company offers exceptional opportunities to physicists and engineers in the fields of system design, electronics, mechanics, optics, missile flight test, reliability, and product engineering.

If you have sound experience and the qualifications to assume the technical responsibility for challenging and complex tasks, you should investigate this small but dynamic organization located in the heart of the San Fernando Valley. The H. A. Wagner Company has an enviable record for its conception, design and development of tracking systems and optical missile guidance systems. One of its present activities is the development of the guidance system for the DART anti-tank missile.

These positions offer a rare chance to progress with an expanding company, important in its field but small enough to retain the individual identity of its members.



Engineers who have the background and experience and desire to join such a company are invited to write or telephone *Edwin Gage*, STate 6-1090.

H.A. WAGNER COMPANY

Developers of Missile Guidance and Tracking Systems . . . Simulators and Trainers

14707 KESWICK ST., VAN NUYS, LOS ANGELES COUNTY, CALIF.

new equipment and processes

EQUIPMENT

Electrical, Electronic

Rate Gyroscope: Type GN miniature rate gyroscope is suited for autopilot damping, radar antenna stabilization and fire control applications. It is 1 in. in diam, $2^1/_4$ in. long and weighs 3.8 oz. Minneapolis-Honeywell, Boston Div., 1400 Soldiers Field Rd., Boston 35, Mass.

•

Altimeter: Accurate in the ranges from 75,000 to 225,000 ft, the Hastings altimeter offers wide possibilities of accurate measurements for altitude chambers, wind tunnels, environmental testing, aircraft, and rocket and missile research. It uses 15 volts ac and provides continuous direct reading or recording. Hastings-Raydist Inc., Hampton, Va.

•

Time Dwell Servo Valve: A $1^1/_4$ lb unit which converts electronic signals into control forces for guided missiles has been developed. It serves as a link between a missile's electronic computer and control surface actuators regulating the flight path. It converts electric signals from the computer into hydraulic forces that move the actuators. Garrett Corp., AiResearch Mfg. Div., Los Angeles, Calif.

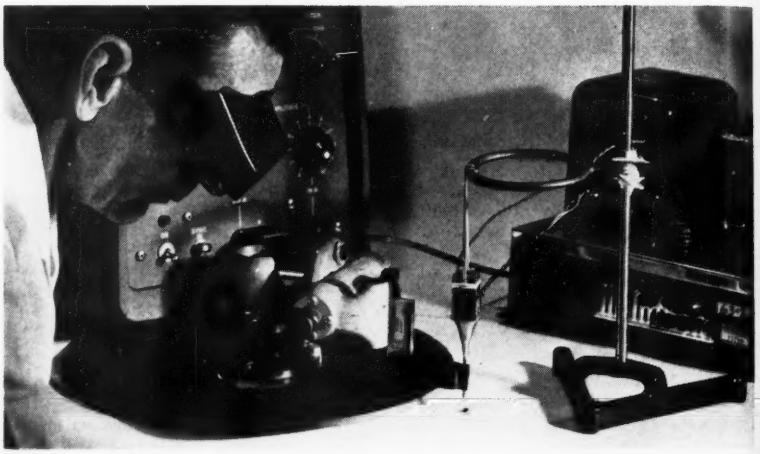
•

Pull-Type Solenoid: A miniature solenoid for missile and electronic applications operates with high efficiency and low plunger friction loss. With operating temperatures ranging from —65 to 100 F, the solenoid provides positive operation on computing devices or missile components at high altitudes and high speeds. The unit meets requirements of MIL-S-4040. Operating voltage is from 6 to 11 volts dc, with plunger operating under side force of 8 to 10 g. Carruthers & Fernandez, Inc., 1501 Colorado Ave., Santa Monica, Calif.

•

Transistor Clip: A clip designed to retain all popularly used transistors under conditions of severe acceleration, deceleration, shock and vibration is made from tempered beryllium copper. The clip performs a dual function of retention and heat dissipation. Offered in cadmium, black ebanol or silver plate, it is available in many sizes and modifications. Industrial Div., The Birtcher Corp., 4371 Valley Blvd., Los Angeles 32, Calif.

•



Sound Wave Power: Silent sound waves are being used by scientists to drill holes as small as 0.005 in. in materials high speed drills can not scratch. The sound waves power a drill specially designed to bore holes in very hard ferrite materials. The drill was devised for precision missile work at Lockheed Missile Div.'s research and development center. The ultrasonic frequency operates the drill with a jack-hammer type action.

Acceleration - Sensitive Switch: Model DDS acceleration-sensitive switch is readily adapted for precision instrumentation requirements in guided missiles. The magnetically damped oil-filled instrument is obtainable in ranges from 0.01 g to 30 g. The switch will open or close the switch circuit at any g value specified, or for multiple g values. Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.

•

Rotary Solenoid: A Ledex rotary solenoid that can withstand high ambient temperatures to 5000 F solves remote control problems involving high temperatures, including various guided missile applications. It has a life expectancy of 300,000 snap-action operations at 500 F. Other advantages include ability to operate with higher wattage inputs to produce higher torques, and use in radioactive atmospheres. Eight basic sizes are available, ranging from 1 to $3^3/_8$ in. diam. G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio.

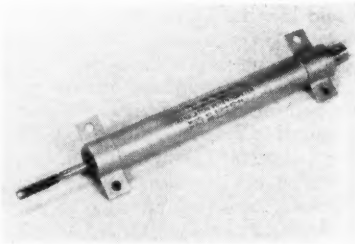
•

Electronic Commutator: Series ETC-30 electronic commutator for airborne telemetry applications is offered with any sampling rate from 75 to 900 points per sec. It may be used as a direct replacement for mechanical commutators in 0-3 and 0-5 volt systems. Errors due to drift, cross-talk, and nonlinearity are less than 0.50%. Power required is 150 volts dc at 12 milliamp. Size is 3 in. diam by 5 in.; weight is less than 2 lb. Arnoux Corp., 11924 W. Washington Blvd., Los Angeles, Calif.

•

Ceramic Switch: Occupying less than $1^1/_2$ sq in. of panel space, Series M switch can be ganged up with eight decks. One, two or three poles per deck may be obtained as standard. The switch contains up to 18 positions on a single wafer. Solid silver alloy contacts, rotors and slip rings provide low and uniform contact resistance. Ceramic parts are silicone-impregnated to function under extreme humidity. These switches find a variety of applications on guided missiles. The Daven Co., Livingston, N. J.

•

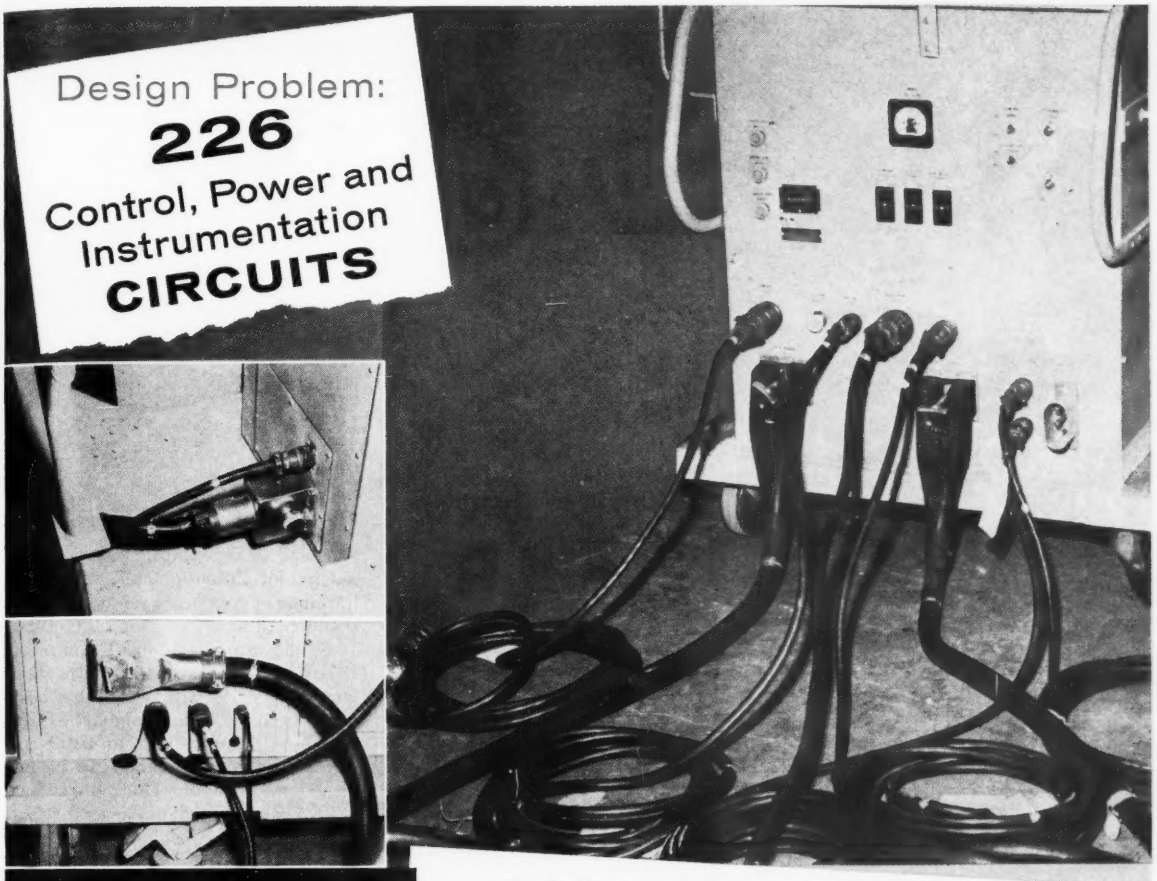


Rectilinear Potentiometer: Accurate operation under vibration environments to 20 g is offered in the

Design Problem:

226

Control, Power and Instrumentation CIRCUITS



SPECIFICATIONS

ELECTRICAL

Capacitance load within cable held to 40 uuf/ft • Cross talk attenuated to a 40 db level • Voltage breakdown 3000V • Leakage resistance 75 megohms/1000 ft. maximum • Conductor sizes and types: #22; #22-TPSJ • Floating shields.

PHYSICAL

Diameters: ¾" to 1 1⁵⁄₃₂" • Lengths: 2' to 1000' • Cable Configuration: 6, 9, 10, 12, 24, 41, 61 and 63 conductors •

Connectors:
AN type A and B
Cannon DPD2
1) Molded 90° attachment } Each with mechanical engaging mechanism
2) Metal back shell

Bend radius: Four times cable diameter, retaining flexibility at –65°F.
Conductors: Number coded every 2" inside of cable.

ENVIRONMENTAL

Reliable operation from –65°F. to +200°F. Neoprene jacketed to withstand severe abrasion: trucks running over cable; dragging along rough ground; burial.

Resistance to oils, fuels, acids, liquid oxygen, fungus, ozone and sunlight.
Completely waterproof and submersible.

Solution: **8 RELIABLE, COMPACT, VERSATILE PACIFIC AUTOMATION PRODUCTS Engineered Electronic Cables**

The eight electronic cables installed on the above junction box comprise the 226 vital control, power and instrumentation circuits for check-out of the Chance-Vought REGULUS I MISSILE.

They were designed and manufactured by Pacific Automation Products who assisted development engineers in the design of this system—keeping the number of cables to a minimum, fulfilling the circuitry requirements, preserving functional versatility, and maintaining reliability under exacting operating conditions.

The criteria governing Pacific Automation Products' concept of a system design are as follows: 1) proven reliability; 2) maximum versatility; 3) minimum number of cables; 4) mutual interchangeability. This concept guarantees optimum performance and maximum reliability.

Pacific Automation Products' engineers give consideration to all contingencies in the design of the cable system; as an example, the electrical, physical and environmental conditions stipulated to the left, in the design of cables for the Chance-Vought REGULUS I GROUND SUPPORT SYSTEM.

Engineers and technicians are invited to investigate career opportunities with us. Submit resume for interview.

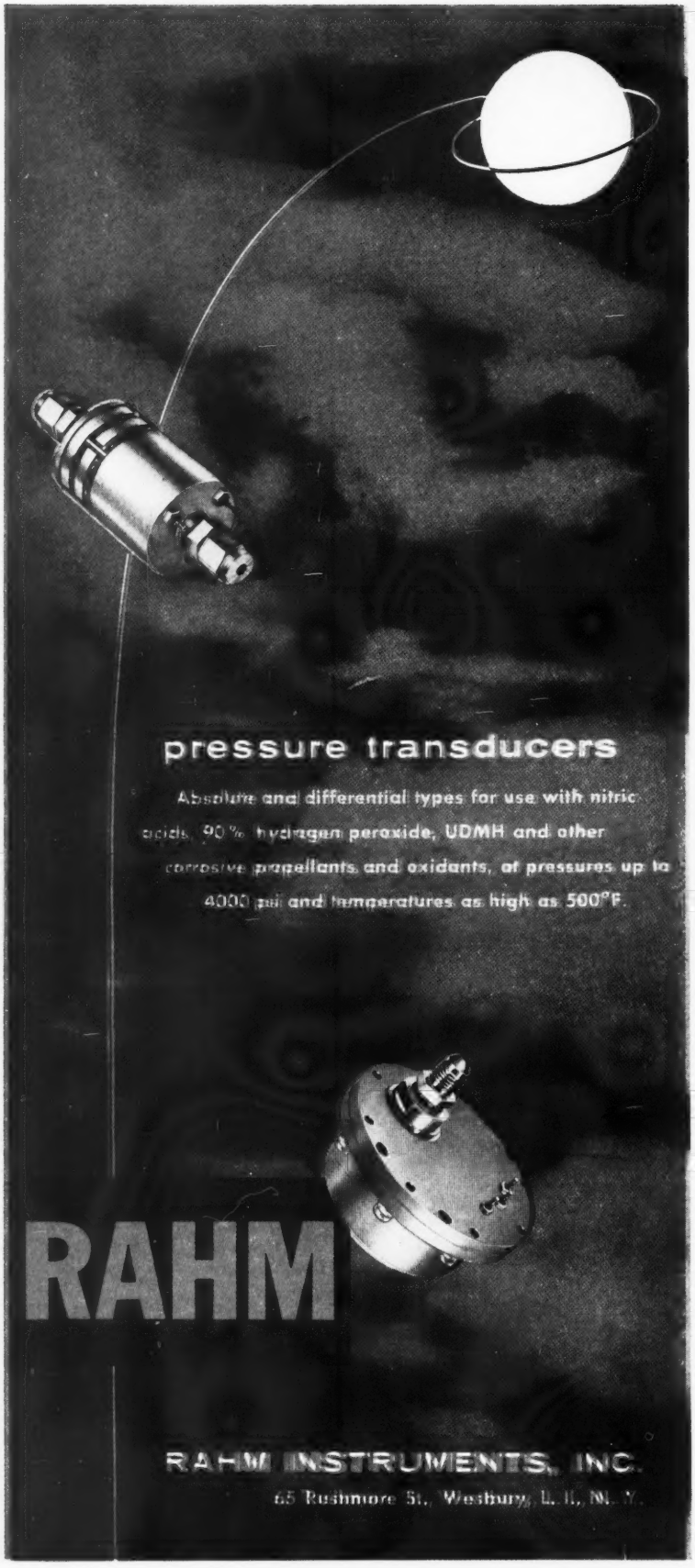
Engineering representatives will be pleased to discuss your design problems, when you visit them at Booth 159 — Air Power Panorama, Washington, D.C., July 31-Aug. 3; Booth 2412 — WESCON Show, San Francisco, Aug. 20-24.

For further information, write for Bulletin 168

PACIFIC AUTOMATION PRODUCTS, INC.

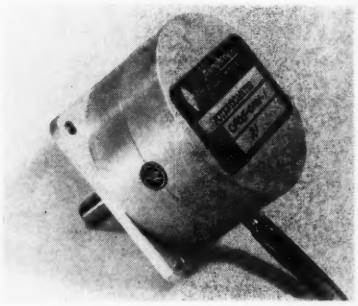
1000 Air Way, Glendale 1, Calif. • CHapman 5-6871—TWX: GLN7371

137 Walnut Hill Village, Dallas, Texas • FLeetwood 2-5806
420 Lexington Ave., New York 17, N.Y. • LExington 2-5193


pressure transducers
Absolute and differential types for use with nitric acids, 90% hydrogen peroxide, UDMH and other corrosive propellants and oxidants, at pressures up to 4000 psi and temperatures as high as 500°F.
RAHM
RAHM INSTRUMENTS, INC.
65 Rushmore St., Westbury, L. I., N. Y.

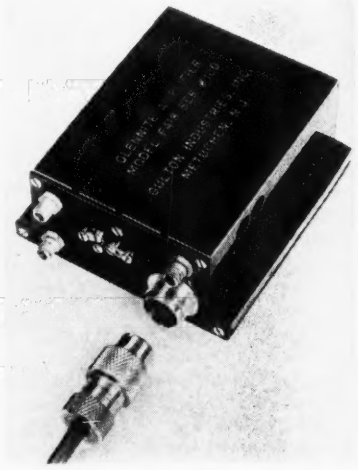
Model G rectilinear potentiometer. Designed primarily for airborne service, external portions are of stainless steel. Lead wires are teflon covered and insulated. The unit will operate in temperatures to 400 F. Available in ranges from 0.5 to 10 in. with resistances from 500 to 10,000 ohms. Servonic Instruments, Inc., 1145 S. Fair Oaks Ave., Pasadena, Calif.

•



Circular Potentiometer: Designed for missile systems, a circular potentiometer designated Type CP05-0101-1 is moisture- and explosion-proof. It has a $1^3/_4$ in. sq base, and a stainless steel shaft with Graphitar bearings. Temperature range is −65 to 400 F, vibration 10 g to 2000 cps. The 10,000-ohm winding can be furnished with taps. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.

•



Miniature Amplifier: Model F-418 Glennite amplifier is designed specifically for use in missiles. Employed in the units are rugged subminiature tubes, individually selected for low microphonics. The amplifier provides for variable gains from 10.2 to 99.5 and fixed gains from 10 to 100, constant over a wide range of plate voltages. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.

•

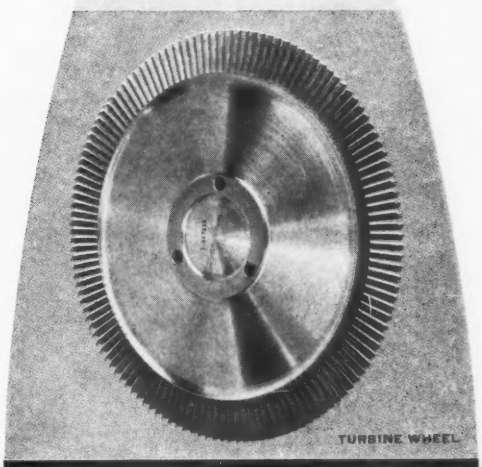
D-C Signal Amplifier: Micromag MMO-528 magnetic low-level d-c

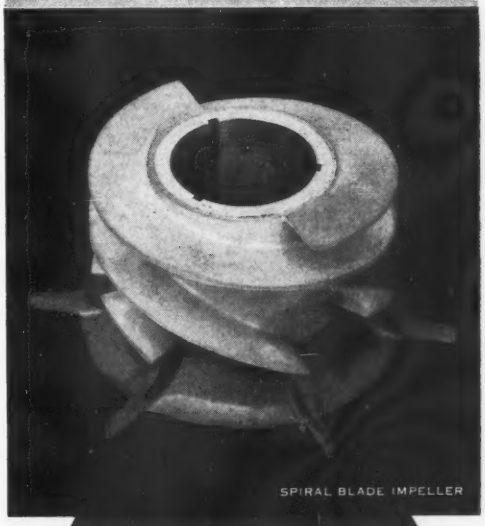
IMPORTANT ENTRIES INTO AN IMPORTANT FIELD

HOUSTON FEARLESS PRODUCES: *Two New Precision Rocket Components...*

THE TURBINE WHEEL—A highly complex unit cut out from a single block of steel to precise dimensional requirements. Manufactured by Houston Fearless designed automatic tools. These turbine wheels are produced for various guided missile power plants.

THE SPIRAL BLADE IMPELLER—Intricately designed to meet the most rigid military specifications, the spiral blade impeller has a variety of applications within commercial installations. These pumping units for guided missiles are manufactured by Houston Fearless designed variable pitch generating machines.


TURBINE WHEEL


SPIRAL BLADE IMPELLER

Houston Fearless Also Manufactures These Highly Important Rocket Components:

HIGH PRESSURE PNEUMATIC REGULATORS—Designed for self-contained starter systems and for pneumatic ejector systems.

ROCKET ENGINE MOUNTING FRAMES—Tubular weldments are available for any size of power plant.

PRECISION DUCTING—Engineered for test installations or for power plants.

TRI-AXIAL NODAL POINT CAMERA MOUNT—Designed for ribbon frame cameras and used in conjunction with recording missile flight. Covers a full hemisphere.

For further information on any or all of these components, send in attached coupon today.

HOUSTON FEARLESS, Department A-8
11801 W. Olympic Blvd., Los Angeles 64, Calif.

Please send me detailed information on:

☐ Turbine Wheel ☐ Tri-Axial Camera Mount
☐ Spiral Blade Impeller ☐ Rocket Engine Mounting Frames
☐ High Pressure Regulators ☐ Precision Ducting

Name_____
Company_____
Position_____
Address_____
City_____ Zone_____ State_____

HOUSTON FEARLESS

signal amplifier is capable of operating from a 28-volt missile system. The unit has a built-in transistor oscillator which generates its own frequency, enabling operation from a d-c source. It is free from the ±10% variations normally present when excitation is provided by an a-c line supply. Designed for amplification of signals from thermocouples, strain gages and similar low-level transducers, the amplifier has practically no zero lift. Magnetic Sales Corp., Sales Engineering Dept., 3106 W. El Segundo Blvd., Hawthorne, Calif.

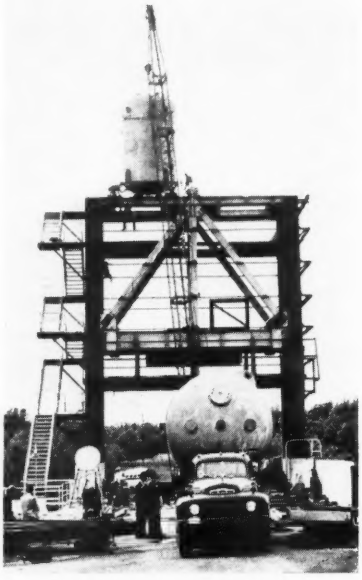
•

Power Supplies: Transistorized d-c converters with an operating temperature range of −55 to 85 C, and meeting MIL-E5400 specifications, are available in units up to 300-watt output. They are the smallest size and weight produced for missiles. A 75-watt unit measures $4^1/_4$ by $1^1/_4$ by $2^3/_4$ in., and weighs 11 oz. Metal construction is confined to the cadmium plated base plate. Rho Engineering Co., 2242 Sepulveda Blvd., Los Angeles 64, Calif.

Ground Support

Pressurizing Stand: High pressure dry air or other gases for pressurizing missile systems or for starting jet engines are provided by the Model KC-1037 air stand. A four-stage compressor delivers 15 cfm of dry air at pressures up to 5000 psig. A high pressure automatic dryer provides a dryness of −65 F or lower dewpoint. An ICC-3AA 6000-lb cylinder is included for gas storage. For rocket and missile applications, equipment is provided for boosting nitrogen to 5000 psig. All electrical equipment may be explosion-proof if required. Kahn and Co., Inc., 541 Windsor St., Hartford 1, Conn.

•



Fuel Tanks: Stainless steel pressure vessels for storing liquid oxygen in capacities of 3800 and 7600 gal were made for North American Aviation for use in rocket engine testing work at the Rocketdyne Div. plant in Neosho, Mo. In forming the heavy gage shells, special care is taken and unusual welding techniques used. Seams are tested by x-ray. Charpy impact tests are performed to determine acceptability of materials and welding at temperatures of −300 F. Standard Steel Corp., 5001 S. Boyle Ave., Los Angeles 58, Calif.

Materials

Plymetal Sandwich: Stronger primary structures for missiles are permitted by use of a prestiffened resistance welded high temperature plymetal sandwich. The material lends itself to economical production in quantity. Missile Development Div., North American Aviation, Inc., 12214 Lakewood Blvd., Downey, Calif.

•

Rigidized Teflon: Additions to Teflon used in making Enflon reinforce it and give higher tensile strength, lower coefficient of thermal expansion and lower heat distortion. Used for bearings, inserts and related applications, it permits high unit loading and close tolerances. Enflo Corp., Route 38 at Airport Circle, Pennsauken, N. J.

•

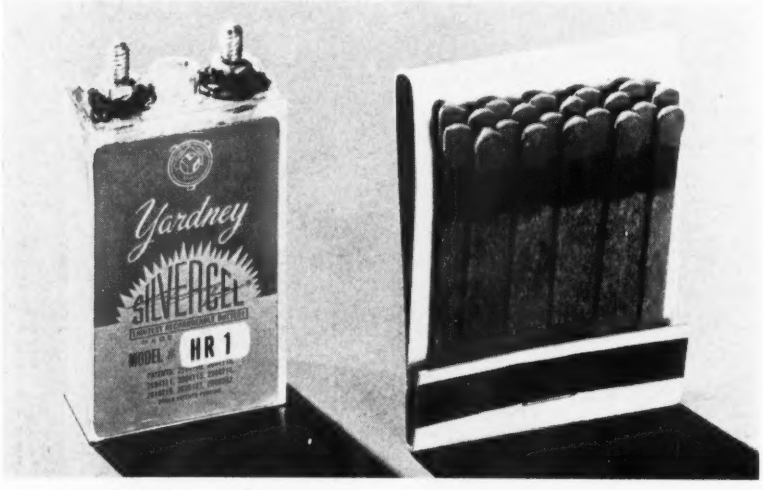
Plastic Missile Structure: One of the first sandwich-type, load-carrying missile structures fabricated of reinforced plastics has recently undergone severe static tests successfully. The test component, approximately 5 ft diam and 8 ft long, weighed only 71.5 lb, against 166.9 lb for a metal counterpart. It tested to 200% of ultimate load at 650 F. Narmco, Inc., San Diego, Calif.

•

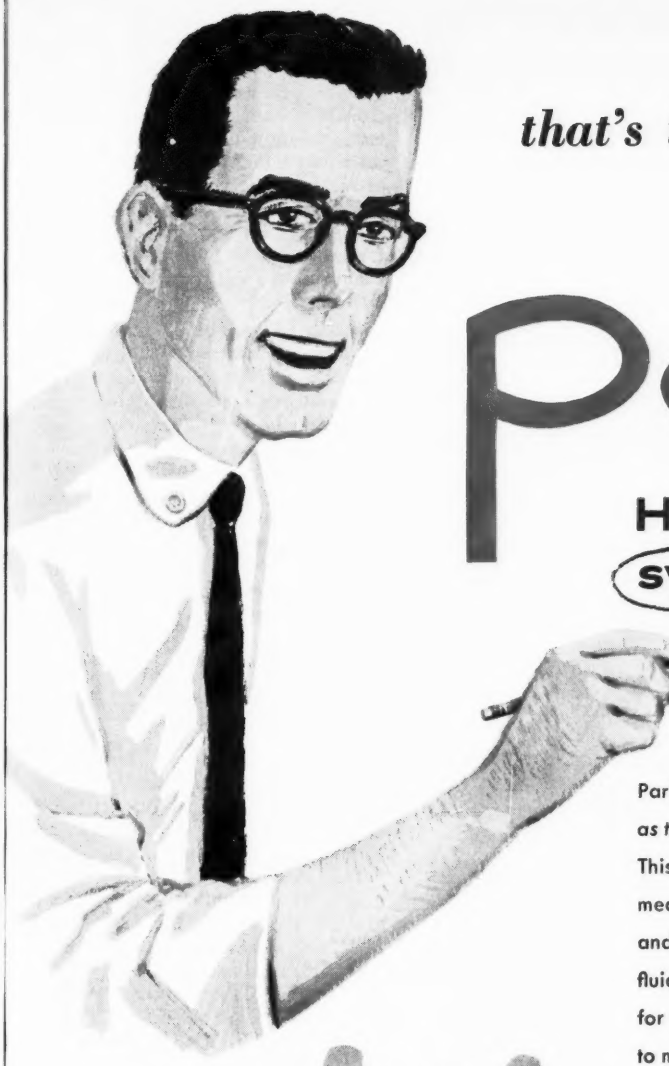
Ceramic for Seals: Ceramicite, a ceramic material for hermetic seal applications at high temperatures, bonds physically to most stainless steels. Thermal expansion of the material is similar to these metals. It is available as pre-formed pieces and as completed seal components. Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

•

Insulating Fabrics: Two types of high temperature insulating fabrics for service up to 1500 F have been announced. Made of Fiberfrax ceramic fiber (Carborundum Co. product) the fabrics are available in various widths or thicknesses, and are also supplied as instrumentation tapes for both insulation and leak detection. The tapes consist of two stranded Chromel wires covered with reinforced ceramic fiber. In event of a leak, the tape causes an alarm-sounding short circuit. Renner, Inc., 1530 Lombard St., Philadelphia 46, Pa.



Missile Batteries: Silvercel batteries, which can be as small as one-fifth the size and one-sixth the weight of other batteries, provide as much or more power, serve as basic sources of high energy for servo controls and guidance systems in missiles. Silver-zinc cells range from the stamp-sized $^1/_7$ oz Model HR 1 with a normal capacity of 0.1 amp-hr, the LR300, and even larger special-built batteries. The batteries are made by Yardney Electric Corp., 40 Leonard St., New York, N. Y.



that's the word, sir...

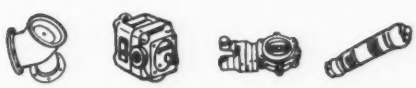
Parker

Hydraulic and fluid system components

Parker *specializes* in hydraulic and fluid problems *as these problems apply to* ***your*** *SYSTEM.*
This is called "Parker's system approach." What does it mean to you? Just this: Parker's leadership in experience and design is at your disposal to make sure that your fluid and hydraulic system components are exclusively for ***your*** system—*an integral phrase of that system*—to make sure that the *whole* performs exactly to requirements—or *better!* Why not ask us how the Parker "system approach" can save you precious engineering lead time and effort?

let a Parker team help you!

The Parker Team provides specialized viewpoints to get the right answers. It's the first step in the "systems approach" . . . gives a Parker customer the plus value of leadership in experience, for today's *AND TOMORROW'S* fluid and hydraulic problems.



check valves · hydraulic valves · fuel valves · accumulators

Parker Aircraft Co., Los Angeles 45, Calif. • Cleveland 12, Ohio
(Subsidiary of The Parker Appliance Company)

Mechanical

Lox System Valve: Valve 7025 is a pressure build-up and vent valve for use in 70 and 300 psi aircraft liquid oxygen systems. The toggle handle action operates freely even at temperatures of −297 F. Reduced gas port and vent port leakage is less than one-tenth of that allowable under specification requirements. Airborne Research and Development Corp., Sun Valley, Calif.

PROCESSES

Descaling Stainless Steel: A process for descaling precipitation hardened 17–7 PH stainless steel after it has received the transformation hardening cycle has been developed by Turco. It renders the surfaces processed chemically clean and causes a metal loss of only 0.0002 in. per side. Turco Products, Inc., 6135 South Central Ave., Los Angeles 1, Calif.

•

Decaborane Production: American Potash and Chemical Corp. has begun production of decaborane. This high energy fuel (see Jet Propulsion, May 1957, p. 553) is highly reactive and, on burning, generates 28,000 Btu of heat per lb. The new product is offered for sale in limited quantities for investigational purposes by industry. American Potash and Chemical Corp., Henderson, Nev.

•

Titanium Alloy Spinning: First use of a hot spinning process is in production forming of titanium alloy hemispheres 25 in. diam and with gage thicknesses greater than $^1/_4$ in., using inexpensive dies. The hemispheres are then welded, forming spherical pressure vessels for storing oxygen, helium or carbon dioxide. Titanium Fabricators, Inc., Burbank, Calif.

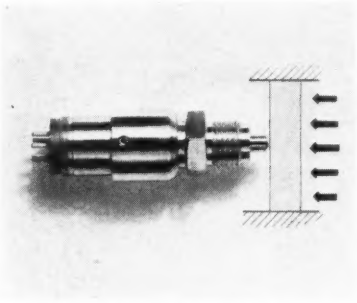
Test

Jet Fuel Tester: The Erdco jet fuel coker is used to evaluate jet fuels under prescribed conditions. Test fuel is pumped through a heat exchanger. Hot fuel then passes through a heated sintered steel precision filter. Fuel flow rate, fuel temperature and filter temperature can be varied to control test severity. Insoluble sediment formed during the heating operation deposits on the filter. Time required to achieve a given pressure drop across the filter is a measure of fuel stability. Erdco Engineering Corp., Addison, Ill.

•

Porosity Measurement: The quality and performance of any substance that has pores—metals, fuels, plastics, chemicals, ceramics and many others —can be measured with the Porosimeter. Portable, and made of stainless steel, the instrument measures the sizes of pores in materials with pores ranging from 0.1 mm to 0.06 microns, and determines pore volumes as small as 0.0005 ml at each pore diameter. American Instrument Co., Inc., Silver Spring, Md.

•



Force Pickup: A new line of strain-gage force pickups measures forces in applications where the deflection caused by the force is limited to 0.00035 in. They measure sudden forces applied to rigid physical structures such as rocket launching platforms. Either compression or tension may be measured, depending on how the instrument is mounted. Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge, Mass.

•

Combined Computer: The Addaverter, a machine that "speaks" in both analog and digital terms, is making possible faster, more flexible and highly accurate calculations. Developers of the Addaverter, Convair-Astronautics and Epsco, have mated the two computer systems, uniting the best features and decreasing the disadvantages of each. The new computer is capable of great accuracy without the usual deterioration at low signal levels. Epsco, Inc., Boston, Mass.

•

Tape Reader: Combining the advantages of both tape and card readers, the Tape-ard Reader can simultaneously read 10 transverse rows of eight holes each in a perforated tape. Providing the convenience in handling data in a fixed sequence afforded by tape, the unit can supply 80 bits of information for each event without use of memory circuits. Applications include the programming of automatic production and test equipment. California Technical Industries, 1467 Old Country Rd., Belmont, Calif.

•

Strain Viewer: Flinn strain viewer permits microscopic examination of metals and other solids under stress. The unit has a specimen table with a knife-edge loading device for the loading of a miniature polished bar of material. Resulting plastic strain and mode of fracture can be viewed at all conventional magnifications including 1000 diameters. Fracture initiation and propagation, slip, twinning and phase transformations resulting from stress can be viewed and photographed. Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.

PRODUCT LITERATURE

Qualification Testing. The organization and technical operations in qualification and reliability testing of missile components and systems are contained in a 100-page volume prepared by staff engineers. Photographs of tests in action provide a tour of the specialized branches of each laboratory. Available when requested on signed company letterhead. Wyle Laboratories, 128 Maryland St., El Segundo, Calif.

Pressure Meter. A catalog on the Press-I-Cell describes an instrument for the precise measurement of absolute, gage or differential fluid pressures. The unit measures gases or liquids over pressure ranges from 0–4 to 0–100 psi with a degree of accuracy as high as one part in 200. Fischer & Porter Co., 99 Jacksonville Rd., Hatboro, Pa.

Systems Manufacture. Describing the McGraw-Edison Systems as contributing to the safety of supersonic flight, the accuracy of guided missiles, the success of automation in thousands of applications, a brochure enumerates some direct applications pioneered and supplied by the company. Thomas A. Edison Instrument Div., McGraw-Edison Co., West Orange, N. J.

Data Sheets for Motors. Bulletin MS 101 is an applications data sheet for motors and elapsed time indicators, and MS 102 is for repeat cycle timers and time delay relays. They are designed to aid customers when order-

ing or requesting information. The A. W. Hayson Co., 232 N. Elm St., Waterbury, Conn.

Hardness Tester. A folder describing the features of the portable 30-oz NEWAGE instrument, which can be used in any position to test the hardness of any shape or type metal, is available. The tester eliminates the need for calculations or conversions, as the dial gives an answer in Rockwell or Brinell ranges. Newage Industries, Inc., 222 York Rd., Jenkintown, Pa.

Metal Fabrication. An illustrated booklet reviews company history and operating methods, and describes Portland Copper's technical advances in the fabrication of stainless steel and high temperature alloys in connection with its work for the aviation and other industries. Sections are devoted to the company's quality control program. Portland Copper & Tank Works, Inc., 80 Second St., So. Portland, Me.

Functional Tester. Features of the Model 250 Functional Testers are described in a folder. The unit makes tracking down and correcting faulty wiring quick and simple. When a circuit error is encountered, the tester stops automatically. A pilot light pinpoints the trouble on a matrix chart. DIT-MCO, Inc., 911 Broadway, Kansas City, Mo.

Corrosion-Resistant Alloys. An elaborate 104-page booklet gives extensive technical data on physical and mechanical properties, corrosion resistance and fabrication of Hastelloy alloys. Tables, charts, diagrams and photographs cover high-strength, heat and corrosion-resistant nickel-base alloys. Haynes Stellite Co., Div. of Union Carbide Corp., 400 Lexington Ave., New York 17, N. Y.

Explosive Actuated Valves. Brochure, based on a talk delivered to the ARS, illustrates and describes variations of explosive valves giving minimum power requirements for operation in aircraft, guided missiles and commercial applications. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

Micro-Bearing Selection. Bulletin 19 contains formulas used to determine rolling distance per bearing revolution. Charts give values for miniature ball bearings, conversion factors, and other technical data. New Hampshire Ball Bearings, Inc., Peterborough, N. H.

Auxiliary Power Systems. An illustrated brochure describes power systems for missiles and manned aircraft. These systems provide electric, hydraulic or other power to actuate critically important devices aboard the vehicle. Walter Kidde & Co., Inc., Aviation Div., Belleville, N. J.

Carbide Grade Data. A series of 15 new Blue Data sheets on Carmet carbide grades is available. Each sheet gives typical applications, analysis, physical characteristics and a photomicrograph showing the grain structure of the carbide powder. Carmet Div., Alleghany Ludlum Steel Corp., 1500 Jarvis Ave., Detroit, Mich.

Transistorized Computer. The completely transistorized Philco Transac type S-2000 computer is described in a 12-page brochure. Illustrations include a typical installation incorporating the compact basic unit containing the arithmetic, control and memory sections. Philco Corp., Government and Industrial Div., 4700 Wissahickon Ave., Philadelphia, Pa.

Fine Pitch Gears. A brochure discusses precision gears compared to commercial gears, and the method and equipment employed in producing the former. A section gives latest recommended gear data formats. Precision Gear Dept., Fairchild Camera and Instrument Corp., Robbins Lane, Syosset, L. I., N. Y.

Liquid Level Switch. Bulletin 381-1 describes a switch utilizing radioactive material in the sensing element for control of fuel levels in supersonic aircraft and missiles. It gives information on construction, operation, applications and specifications. Aeronautical Div., Robertshaw-Fulton Controls Co., 401 N. Manchester Ave., Anaheim, Calif.

Precision Potentiometer. Technical data on a completely enclosed high resolution 2-in.-diam potentiometer is available. The small diameter cylindrical Kohlrausch resistance element is enclosed in a one-piece housing molded of glass reinforced alkyd. Series HP-200 can be supplied singly or as a multiple ganged unit. Power dissipation is 3 watts; mechanical rotation 360 deg. Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Infra-Red Development. Bermite flares, used as decoys for countermeasure purposes, as targets and tracking aids, are described in a booklet. The equipment and instrumentation at Bermite can determine the output of burning compositions in the spectral region from 0.75 to 8 microns, at similated altitudes up to 85,000 ft. Research & Development Div., Bermite Powder Co., Mint Canyon Rd., Saugus, Calif.

High Temperature Research. A folder describes Research Models 80 and 160 Plasmatrons, which at atmospheric pressure produce a jet of inert gas at high temperature and velocity. Included in the folder is a temperature conversion chart to convert Kelvin to Centigrade, Centigrade to Fahrenheit, and Fahrenheit to Rankine. Plasmatron, 18400 S. Main St., Santa Ana, Calif.

Teflon Wire. Samples of high temperature insulations are offered on pocket-size sample cards. Typical samples are teflon and silicone insulated magnet wires, lead wires, sleeving, tubing, shielded and jacketed miniature cables, and multi-conductor cables. Cards may be obtained by writing on company letterhead and specifying type, size and application. American Super-Temperature Wires, Inc., W. Canal St., Winooski, Vt.

Waveguide Pressure Windows. Performance curves, outline dimensions and drawings, and electrical and mechanical data are given in Brochure 57-W. Broadband-width, high power, cover-flange-mounted windows for direct mounting between standard flanges in the frequency range from 2.5 to 75 kmc are listed. Microwave Associates, Inc., Burlington, Mass.

Delay Lines. Data on functions, applications, principal equipment uses, characteristics, specifications, nomenclature, time delay, bandwidth, and rise time, with detailed graphs and illustrations are contained in Bulletin S-2. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Reinforced Plastics. Bulletins describe various uses for plastics in the missile field. Pyrotex products for fabricating missile fins have been subjected to temperatures up to 3000 F. A prototype airfoil for missiles uses Pyrotex felt with resin as the skin of a sandwich structure and has an alkyd isocyanate foamed core. Other applications include rocket launcher bodies or tubes, rocket sliver traps, rocket heads and throats, and fin shrouds. Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa.

Chemical Milling. Bulletin No. 5 reviews how blueprints that provide all essential information can save money and time in fabrication of tooling. The bulletin applies to parts in aluminum, magnesium, stainless steel and titanium. United States Chemical Milling Corp., 1700 Rosecrans Ave., Manhattan Beach, Calif.

Pressure Test File. A technical file on pressure testing, gas and liquid tight vessels or assemblies at pressures to 1500 psi, with picture index, illustrations and detailed information on the design and selection of test plugs and filling connectors has been published. Mechanical Products Corp., 168 N. Ogden Ave., Chicago 7, Ill.

AF Plans Extensive ICBM Tests in Fall

The Air Force has disclosed plans for extensive testing of ICBM's this fall with the announcement that six Army freight supply cargo ships would be used to fill gaps in the chain of missile tracking stations stretching across the South Atlantic from Cape Canaveral to Africa.

Production programs have reportedly been stepped up for the AF intercontinental Atlas and intermediate-range Thor, and a number of IRBM's and ICBM's are said to be ready for launching at Patrick AFB, Fla.

Announcement that the six telemetry ships were being added to the existing chain of island stations was taken to indicate AF confidence that successful Atlas firings are now imminent. The ships will be capable of being "on station" for as long as three weeks. The announcement stressed that they would be used only when missiles were actually being tested.

The ships, remodeled at a cost of more than $2 million, will return to their South American ports of Recife and Belem in Brazil, and Georgetown in British Guiana after each mission.

The present tracking system extends across the Caribbean from the Florida coast to Puerto Rico and from there some 3500 miles to the islands of St. Lucia and Ascension near the African coast. The latest link in the chain, at Fernando de Noronha, off the Brazilian coast, is now being equipped.

Boeing to Set Up Bomarc Training School in Seattle

Boeing Airplane Co. last month announced plans to set up a Bomarc training school in Seattle. To be located on Harbor Island, the school will train Air Force, Boeing and subcontractor personnel in the installation, maintenance and operation of the Bomarc system.

Present schedules call for construction of the school to begin in November, with training starting in July of next year. The school will simulate a regular base, with students going through the steps of fueling the missile, installing it on its launcher, giving it 30-day and six-month checkups, and finally going through a simulated firing.

New Callery Plant

Ground was broken recently for Callery Chemical Co.'s second new midwestern plant. The $4-million plant at Lawrence, Kan., will be equipped to produce boron specialty chemicals for commercial use, as well as HiCal, the company's new high energy fuel for jet aircraft and missiles. The plant is expected to be in production early next year.

New Navigational Aid

Ryan's APN-67 Doppler navigation unit.

Defense Department security restrictions have been lifted from about a dozen types of Doppler self-contained radar navigation systems reportedly capable of use in a modified form for guiding missiles.

Commercial airlines have expressed interest in the systems for long distance flights. Civil models of the Doppler radars are said to be already in the works at two of the four companies in the field: General Precision Laboratory, Raytheon, Laboratory for Electronics and Ryan Aeronautical Co.

Ryan's unit, representative of the systems, was described as "the most advanced continuous-wave radar Doppler system . . . available for aerial navigation." Designated APN-67 by the Navy (with whose help the system was developed), the over-all unit includes, besides radar, a converter, two computers and associated instruments. Functionally it is claimed to be the simplest system available.

Doppler shifts can give the vehicle's ground speed, ground miles and drift angle directly. Integrated with heading data in a navigational computer provides the earth-referenced parameters such as latitude, longitude, ground track, course deviation, true heading, etc.

Ryan's military system, now in pilot line production, weighs 200 lb. Its civilian version should weigh "as little as 100 lb or less," the company said.

Stiffest competitor at this point seems to be GPL, which believes it is the only company "in actual production" of such Doppler navigation systems. Details of the GPL unit, called Radan, were withheld pending security clause changes in its Air Force contract. But the company confirmed reports that Radan weighs about 85 lb and can be delivered to airlines eight to 12 months after the order is placed.

Lockheed Nuclear Research Lab to Open by End of 1958

Lockheed Aircraft Corp.'s nuclear aircraft research laboratory, now under construction in the North Georgia mountains near Dawsonville, is scheduled to be in operation by the end of 1958. Lockheed is building the lab and will operate it for the Air Force.

Lockheed's Georgia Div. is one of two companies working on the development of nuclear aircraft for the Air Force. The other is Convair Div. of General Dynamics at Fort Worth, Tex.

Engineers at Lockheed's Marietta plant are already working on preliminary design studies for nuclear-powered aircraft and the company says it could have a nuclear-powered plane flying within four years after receiving an AF go-ahead.

SAC Airmen Undergo Training on Snark

Key AF officers and civilians from Strategic Air Command units have been undergoing a series of special two-week indoctrination courses on the Snark SM-62 missile conducted by the Training Services Section of Northrop Aircraft.

The courses are designed to familiarize SAC, as well as Air Materiel and Air Training Command, representatives, with the over-all weapon system, including the missile itself, ground support equipment, depot operations, field service, mission, planning, publications and training. Instruction is aimed at providing a working knowledge of Snark from an administrative standpoint.

The Air Force announced last month that Northrop had received a $73 million production contract for Snark missiles.

Tests Held on Boeing Supersonic Wind Tunnel

Initial testing of Boeing Airplane Co.'s new $2-million supersonic wind tunnel at Plant 2 in Seattle got under way last month. The tunnel is being checked out in preparation for actual supersonic aircraft testing at speeds ranging from Mach 1 to Mach 4. Boeing's original tunnel is larger by far than the new one but its speed capacity is only slightly above Mach 1.

American Rocket Society, Inc.

500 Fifth Avenue, New York 36, N. Y.

Application for Membership

FOR OFFICE USE ONLY

No.

Adm.

Ref.

Cert.

To the Membership Committee:

I hereby apply for membership in the AMERICAN ROCKET SOCIETY, INC., and enclose $———— as my annual membership dues, $5.00 of which is for a year's subscription to AMERICAN ROCKET SOCIETY publications. The information given herewith is correct to the best of my knowledge.

Check type of membership desired (see other side for qualifications)

☐ MEMBER—annual dues $15.00

☐ ASSOCIATE MEMBER—annual dues $15.00

☐ STUDENT MEMBER—annual dues $5.00

Date ————————

Signature in Full ————————

Sign with pen—Do not use initials

Personal Information

PLEASE PRINT OR TYPE

Name ———— Title (or military rank)

Organization or School

Services or Products of Organization

Your Duties and Responsibilities

Organization Address ☐

Home Address ☐

Check Address for Society Mail

Age Date of Birth Country of Birth Citizen of

Other Technical Organization Memberships

Educational Record

Secondary School Date

College or University Date

Major Subject Degree Received Date

Names of other Technical Schools or Colleges

Additional Degrees By Whom Conferred Date

References

Name three and include addresses. Include at least one ARS member if possible.

(Over)

BUFFALO AND ERIE COUNTY PUBLIC LIBRARY
DEPARTMENT OF TECHNOLOGY

Professional Record (Optional for Student Member Applicants. If space is inadequate add supplementary sheet of this size.)

Dates: from	to	Names and addresses of past employers. Your positions, duties and responsibilities.

Memberships

MEMBER: Members shall consist of engineers and scientists who are actively engaged in the development or application of rocket or jet propulsion, other persons who have been working on the development or application of rocket or jet propulsion for at least four years and who hold or have held responsible positions in these fields, and such persons as may be deemed eligible for this class of membership by the Board of Directors by virtue of their outstanding accomplishments in other fields and their unusual interest in the purposes of the SOCIETY.

ASSOCIATE MEMBER: Associate Members shall consist of persons, other than students, who are actively interested in the development or application of rocket or jet propulsion.

STUDENT MEMBER: Student Members shall consist of persons not less than 17 years of age whose principal occupation is study at a recognized educational institution or who are serving as enlisted personnel in the Armed Forces of the United States, and who are interested in the development or application of rocket or jet propulsion.

CORPORATE MEMBER: Corporate Members shall consist of educational, scientific, or industrial organizations who may choose this method of expressing their interest in the development or application of rocket or jet propulsion, and who are considered acceptable by the Board of Directors. Each Corporate Member shall be entitled to five representatives with the rights and privileges of Members. (Write for special Corporate Membership application form.)

Top photo shows missile tank constructed of two forged and machined end caps and center section of tubing. Middle photo shows assembled tank. The *Uniwelds* are located in the approximate center of the bright machined bands. Bottom photo shows a tank that has been pressured to bursting with 2½ times normal operating pressure. Note that the split crosses both weld planes with no tendency to divert and follow the weld—graphic proof of 100% parent metal weld strength.

...NKS called for

...Pioneering, too!

...ENASCO

UNIWELDS

PROVI... FULL

...UTILIZATION

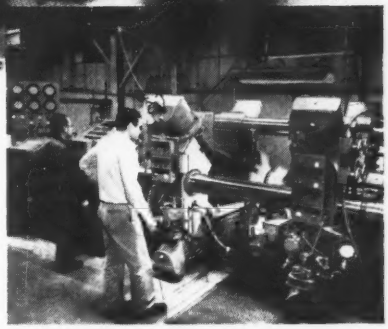
...ALL

...ESSELS

Missile components, like the overall Missile System, have demanded that their designers and engineers pioneer with fresh thinking and new ideas in order to keep abreast of modern guided missile research and development. A case in point is MENASCO'S design and production of air tanks for the Nike missile featuring MENASCO'S now-famous *Uniweld* process, an exclusive method of pressure welding.

The twelve-inch diameter welds in the Nike tank fuse in two operations approximately 34 square inches of alloy steel. Because the *Uniweld* maintains parent metal strength, no increase in local wall thickness is needed and the tank becomes virtually a one-piece vessel.

Thus, MENASCO'S pioneering work in *Uniwelding* of missile tanks has opened entire new fields of pressure vessel applications where high strength welds make the difference.



One of MENASCO'S *Uniweld* machines in operation. This exclusive MENASCO process is gaining wide acceptance in the aircraft and missile fields.

Specialists in Aircraft Landing Gear

menasco manufacturing company

805 SOUTH SAN FERNANDO BOULEVARD, BURBANK, CALIFORNIA

Index To Advertisers

Aerojet-General Corporation ..... Back Cover
D'Arcy Advertising Agency Co., Los Angeles, Calif.

Aeroscience, Inc. 84
Richard W. Hess & Co., Los Angeles, Calif.

American Machine & Foundry Company 19
Fletcher D. Richards, Inc., New York, N. Y.

American Potash & Chemical Corporation 101
The McCarty Co., Los Angeles, Calif.

Ampex Corporation 15
Boland Associates, San Francisco, Calif.

Amphenol Electronics Corporation 108
Burton Browne Advertising, Chicago, Ill.

Applied Science Corporation of Princeton 32
Paul M. Healy Advertising Agency, Montclair, N. J.

Arma Division,
American Bosch Arma Corporation ..... Third Cover
Doyle, Kitchen & McCormick, Inc., New York, N. Y.

Atlantic Research Corporation 105

Avica Corporation 105
Knight & Gilbert Inc., Providence, R. I.

Bell Aircraft Corporation 27
Baldwin, Bowers & Strachan Inc., Buffalo, N. Y.

Bendix Aviation Corporation
Bendix Computer Division 17
The Shaw Co., Los Angeles, Calif.

Cannon Electric Company 103
Willard G. Gregory & Co., Los Angeles, Calif.

Convair,
A Division of General Dynamics Corporation 11
Hixson & Jorgensen, Inc., Los Angeles, Calif.

Cooper Development Corporation 26
Allen, Dorsey & Hatfield, Inc., Los Angeles, Calif.

Diversey Engineering Company 9
Roark & Colby Advertising, Chicago, Ill.

G. M. Giannini & Company, Inc. 75
Western Advertising Agency, Inc., Los Angeles, Calif.

Hallamore Electronics Company 6
Getz and Sandborg, Inc., Beverly Hills, Calif.

Hexcel Products Inc. 128
Peter Hurst Advertising Inc., San Francisco, Calif.

Houston Fearless Corporation 117
Anderson-McConnell Advertising Agency, Hollywood, Calif.

Hydromatics, Inc. 4
Industrial Marketing Associates Advertising, Hicksville, N. Y.

Industrial Acoustics Company Inc. 106
Ritter, Sanford & Price, Inc., New York, N. Y.

Interelectronics, Inc. 30
Corbin Advertising Agency, New York, N. Y.

Kato Engineering Company 98
Frizzell Advertising Agency, Inc., Minneapolis, Minn.

Land-Air Company 102
The Admaster Associates, Barrington, Ill.

Librascope, Inc. 23
Western Advertising Agency, Inc., Los Angeles, Calif.

Lithium Corporation of America, Inc. 91
Keystone Advertising Inc., Minneapolis, Minn.

Lockheed Aircraft Corporation
Missile Systems Division 77
Hal Stebbins, Inc., Los Angeles, Calif.

Loral Electronics Corporation 111
Richard & Gunther, Inc., New York, N. Y.

The Martin Company 87
VanSant, Dugdale & Co., Inc., Baltimore, Md.

Menasco Manufacturing Company 125
The McCarty Co., Los Angeles, Calif.

Minneapolis-Honeywell Regulator Company 97
Foote, Cone & Belding, Chicago, Ill.

Networks Electronic Corporation 29
The McCarty Co., Los Angeles, Calif.

New Departure,
Division of General Motors Corporation 25
D. P. Brother & Co., Detroit, Mich.

Non-Linear Systems Inc. 85
West-Marquis, Inc., Los Angeles, Calif.

Pacific Automation Products, Inc. 115
Mann Advertising Co., Inc., Los Angeles, Calif.

Pacific Valves, Inc. 94

Parker Aircraft Company 119
The Lester Co., Los Angeles, Calif.

Philco Corporation 21
Maxwell Associates Inc., Philadelphia, Pa.

Potter Aeronautical Corporation 81
Richard & Gunther Inc., New York, N. Y.

Rahm Instruments, Inc. 116
Richard & Gunther Inc., New York, N. Y.

Ramo-Wooldridge Corporation 24
The McCarty Co., Los Angeles, Calif.

Rand Corporation, Systems Development Division 90
Stromberger, LaVene, McKenzie Advertising, Los Angeles, Calif.

Reaction Motors, Inc. ..... Second Cover
The Aitkin-Kynett Co., Philadelphia, Pa.

Remington Rand Univac,
Division of Sperry Rand Corporation 2
Mullen & Associates, Inc., Minneapolis, Minn.

Ronan & Kunzl, Inc. 28

Saginaw Steering Gear,
Division of General Motors Corporation 5
D. P. Brother & Co., Detroit, Mich.

Southwest Products Company 96
O. K. Fagan Advertising Agency, Los Angeles, Calif.

Stratos, A Division of Fairchild Engine &
Airplane Corporation 107
Gaynor Colman Prentis & Varley, Inc., New York, N. Y.

Sundstrand Aviation—Denver 93
William Kostka & Associates, Inc., Denver, Colo.

Telefilm, Inc. 109
Allen, Dorsey & Hatfield, Inc., Los Angeles, Calif.

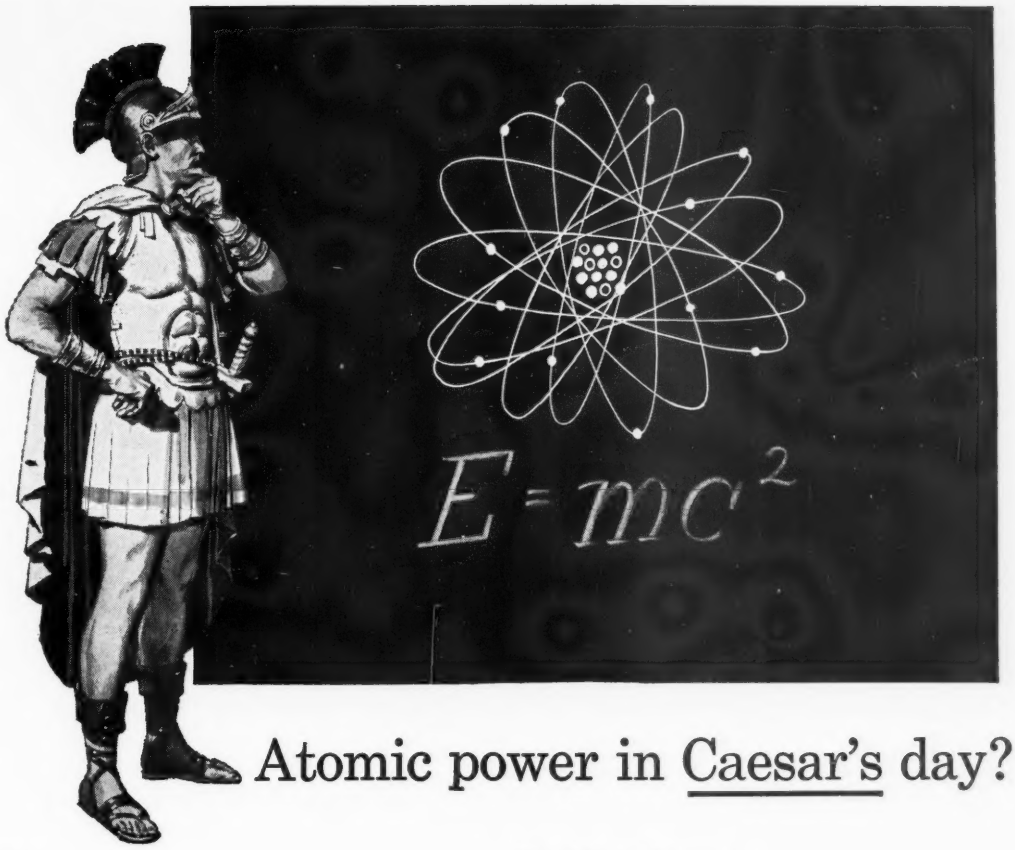
Thiokol Chemical Corporation 99
Kelly Nason, Inc., New York, N. Y.

Thompson Products, Inc., Accessories Division 31
Meldrum & Fewsmith, Inc., Cleveland, Ohio

H. A. Wagner Company 113
Western Advertising Agency, Inc., Los Angeles, Calif.

E. B. Wiggins Oil Tool Company 1
Gaynor Colman Prentis & Varley, Inc., Beverly Hills, Calif.

Franklin C. Wolfe Company 13
The Lester Co., Los Angeles, Calif.



Atomic power in Caesar's day?

Certainly!

It was there, in the ground, in the air and water. It always had been. There are no more "raw materials" today than there were when Rome ruled the world.

The only thing new is knowledge . . . knowledge of how to get at and rearrange raw materials. Every invention of modern times was "available" to Rameses, Caesar, Charlemagne.

In this sense, then, we have available *today* in existing raw materials the inventions that can make our lives longer, happier, and inconceivably easier. We need only *knowledge* to bring them into reality.

Could there possibly be a better argument for the strengthening of our *sources* of knowledge—our colleges and universities? Can we possibly deny that the welfare, progress—indeed the very *fate*—of our nation depends on the quality of knowledge generated and transmitted by these institutions of higher learning?

It is almost unbelievable that a society such as ours, which has profited so vastly from an accelerated accumulation of knowledge, should allow anything to threaten the wellsprings of our learning.

Yet this is the case

The crisis that confronts our colleges today threatens to weaken seriously their ability to produce the kind of graduates who can assimilate and carry forward our rich heritage of learning.

The crisis is composed of several elements: a salary scale that is driving away from teaching the kind of mind *most qualified* to teach; overcrowded classrooms; and a mounting pressure for enrollment that will *double* by 1967.

In a very real sense our personal and national progress depends on our colleges. They *must* have our aid.

Help the colleges or universities of your choice. Help them plan for stronger faculties and expansion. The returns will be greater than you think.

If you want to know what the college crisis means to you, write for a free booklet to: HIGHER EDUCATION, Box 36, Times Square Station, New York 36, New York.

HIGHER EDUCATION

KEEP IT BRIGHT

Sponsored as a public service, in cooperation with the Council for Financial Aid to Education, by

PUBLIC SERVICE ADVERTISING COUNCIL

AMERICAN ROCKET SOCIETY, INC.

Hexcel Honeycomb — the basis for structural materials with the greatest strength-to-weight ratio ever developed.

HEXCEL® PRODUCTS INC.

America's leading producer of honeycomb core materials
951-61st Street, Oakland 8, California

PLANTS: OAKLAND, BERKELEY, CALIF.; HAVRE DE GRACE, MARYLAND • SALES OFFICES: INGLEWOOD, CALIF.; FORT WORTH, TEX.

NO PLACE TO HIDE

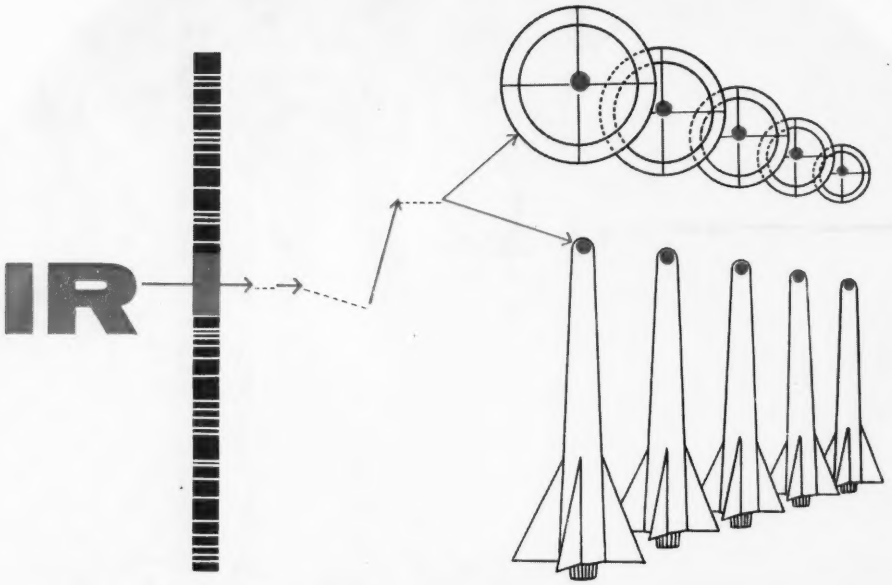
They can run but they can't hide from this *ARMA* Defensive System — the guardian of the B-52.

Called the MD-9, this weapon is just one of *ARMA'S* "sixth sense" systems . . . systems whose "sensing" abilities derive from the integrated use of gyroscopics, radar, optics, computing, pneumatics and hydraulics.

And these "sixth sense" projects provide exciting new areas for engineers. *ARMA* . . . Garden City, N. Y.

AMERICAN BOSCH ARMA CORPORATION

5189



INFRA-RED

1944...RESEARCH • 1957...MASS PRODUCTION

For 14 years Aerojet-General has pioneered the research and development of infra-red devices. *Now*, Aerojet and *Aerojet alone* has perfected the high-volume production of infra-red systems for:

GUIDANCE
WIDE-ANGLE SEARCH
AUTOMATIC TRACKING
GUNFIRE CONTROL

Aerojet-General CORPORATION

A Subsidiary of The General Tire & Rubber Company

THE GENERAL TIRE

PLANTS AT AZUSA AND NEAR SACRAMENTO, CALIFORNIA

MAY 1